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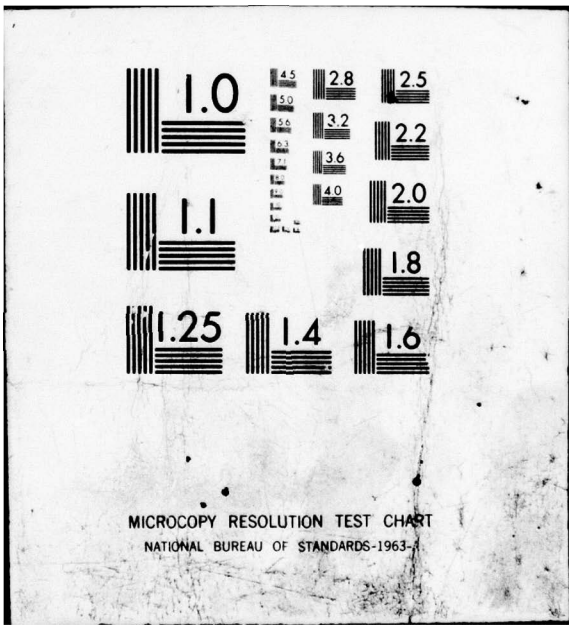
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WANAQUE RIVER, PASSAIC COUNTY
NEW JERSEY

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GREENWOOD LAKE DAM
NJ 00187

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

August, 1979

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18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Spillways
Dams
Visual Inspection
Structural Analysis
National Dam Inspection Act Report
Greenwood Lake Dam, N.J.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, NJ 08621

25 SEP 1979

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Greenwood Lake Dam in Passaic County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Greenwood Lake Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 63 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is one half of the Probable Maximum Flood.) To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. In addition, studies should be undertaken to determine the hydrologic and hydraulic ability of the bridge to withstand overtopping and of the gate house to withstand hydrostatic pressure. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980.

b. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's foundation condition and structural stability. This should include test borings to determine material properties relative to stability. Any remedial measures found necessary should be initiated within calendar year 1980.

c. The seepages noted on the right bank should be investigated within three months from the date of approval of this report. Any remedial measures found necessary should be initiated within calendar year 1980.

d. The following remedial actions should be completed within six months from the date of approval of this report:

(1) Repair all spalled, eroded and cracked concrete with epoxy cement.

(2) Replace the trash screens, restore the lifting gantry and re-open access to the rear gate-house platform.

e. The following remedial actions should be completed within one year from the date of approval of this report:

(1) The existing dam plans and drawings should be annotated and updated to form a coherent as-built set.

(2) All low-level sluice gates should be inspected by a diver. Based on the results of the divers inspection, repair low-level sluices as necessary. The extent of erosion in the monolith joints should be investigated at the same time.

(3) Study the need for and if necessary provide additional low-level discharge facilities.

(4) A formalized program of annual inspections of the dam should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be read during severe rainstorms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance visits to the dam, the lake and the outlet passages. Movement and settlement of the structures should be monitored regularly by means of surveying monuments. All seepage should be monitored.

NAPEN-D
Honorable Brendan T. Byrne

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Robert A. Roe of the Eighth District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Management
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

GREENWOOD LAKE DAM (NJ00187)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 9 and 31 May and 3 June 1979 by Frederic R. Harris, Inc. under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Greenwood Lake Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 63 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is one half of the Probable Maximum Flood.) To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. In addition, studies should be undertaken to determine the hydrologic and hydraulic ability of the bridge to withstand overtopping and of the gate house to withstand hydrostatic pressure. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980.

b. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's foundation condition and structural stability. This should include test borings to determine material properties relative to stability. Any remedial measures found necessary should be initiated within calendar year 1980.

c. The seepage noted on the right bank should be investigated within three months from the date of approval of this report. Any remedial measures found necessary should be initiated within calendar year 1980.

d. The following remedial actions should be completed within six months from the date of approval of this report:

(1) Repair all spalled, eroded and cracked concrete with epoxy cement.

(2) Replace the trash screens, restore the lifting gantry and re-open access to the rear gate-house platform.

e. The following remedial actions should be completed within one year from the date of approval of this report:

(1) The existing dam plans and drawings should be annotated and updated to form a coherent as-built set.

(2) All low-level sluice gates should be inspected by a diver. Based on the results of the diver's inspection, repair low-level sluices as necessary. The extent of erosion in the monolith joints should be investigated at the same time.

(3) Study the need for and, if necessary, provide additional low-level discharge facilities.

(4) A formalized program of annual inspections of the dam should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be read during severe rainstorms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance visits to the dam, the lake and the outlet passages. Movement and settlement of the structures should be monitored regularly by means of surveying monuments. All seepage should be monitored.

APPROVED: James G. Ton
JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 22 Sep 1979

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Greenwood Lake, I.D. NJ00187
State Located:	New Jersey
County Located:	Passaic County
Stream:	Wanaque River
Date of Inspection:	May 9, May 31, and June 3, 1979

Assessment of General Condition

Greenwood Lake Dam is a gravity reinforced concrete dam approximately 240 feet long and 17 feet high, consisting of two unregulated spillways and a central gate-house which controls the low-level sluices. The general conditions of Greenwood Lake Dam is fair. There is evidence of seepage downstream of the dam. Areas of concrete throughout the dam have been eroded and spillway wingwalls, bridge supports and gate-house foundations show signs of minor cracking. The low-level outlets are presently operable. The hazard potential is rated "significant."

The safety of Greenwood Lake Dam is considered questionable in view of its lack of spillway capacity to pass one half the PMF without over-topping the dam. The spillway is capable of passing a flood equal to 31% of the PMF and is assessed as "inadequate."

At present, the engineering data available is not sufficient to make a definitive statement on the stability of the dam.

The following actions, therefore, are recommended along with a time-table for their completion.

1. Investigate the seepage downstream within 3 months. Depending on the results of the investigation, the need for corrective measures can be considered and if necessary, undertaken.

2. Establish a flood warning system for the downstream communities within 3 months, especially for the Hewitt area.

3. Carry out a more precise hydrologic and hydraulic analysis of the dam within six months, to determine the need and type of mitigating measures necessary. If required, conduct a study of the means of increasing spillway discharge capacity and develop alternative schemes for construction. This should include the installation of a tailwater gage.

4. Inspect all low-level sluice gates by a diver within 12 months and repair as necessary. The extent of erosion in monolith joints should be investigated at the same time.

5. Investigate the dam foundation and conduct a stability analysis based on the findings within 6 months.

6. Carry out remedial measures to the dam structure within 6 months, including repair of eroded, cracked and spalled concrete with epoxy cement and restoration of the trash screen gantry.

Furthermore, while of a less urgent nature, the following additional action is recommended and should be carried out in the near future.

1. Existing plans and drawings of the dam should be annotated and updated to form a coherent as-built set.

2. A program of annual inspection and maintenance should be initiated. This should include updating the operation and maintenance log, and monitoring of seepage downstream.

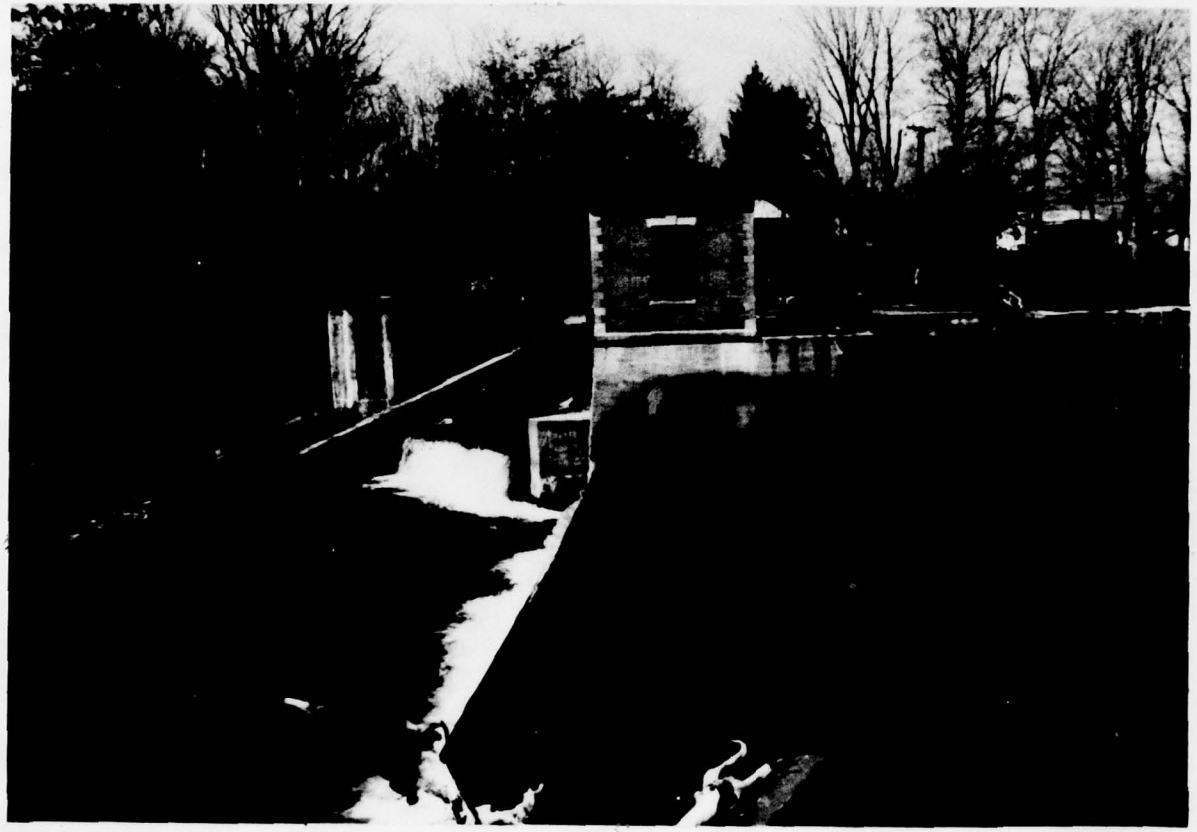
3. Replace the trash screens.

4. Consider providing additional low-level discharge facilities.

A. G. Posch

Anthony G. Posch, P.E.

AGP/REJ/ak



Greenwood Lake Dam
Overall view of dam from left abutment.

May 9, 1979

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

GREENWOOD LAKE DAM, I.D. NJ00187

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act (Public Law 92-367, 1972) provides for the National Inventory and Inspection Program by the U.S. Army Corps of Engineers. This inspection was made in accordance with this authority under Contract C-FPM No. 35 with the State of New Jersey who, in turn is contracted to the Philadelphia District of the Corps of Engineers.

b. Purpose of Inspection

The visual inspection of Greenwood Lake Dam was made on May 9, May 31 and June 3, 1979. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

The report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

1.2 Description of Project

a. Description of Dam and Appurtenances

Greenwood Lake Dam is a reinforced concrete structure approximately 240 feet long and 17 feet high, consisting of the following major components:

1. Left spillway.
2. Gate house
3. Right spillway.
4. Rock abutments.

The left spillway is 90 feet long of ogee shape and is flanked on the left by a natural rock-abutment. On the right, this spillway abuts the gate house building which houses sluice gates and monitoring devices.

The right spillway is located to the right of the gate house and is about 38 feet long overall. It consists of 3 sections, each 10 feet wide, which are separated by concrete piers supporting the foot-bridge to the gate house. Both spillways discharge the water into a stilling basin located downstream. The basin is flanked on the right by a concrete wingwall from the bridge abutments. On the left it is confined by the rock channel bank.

The gate-house is a brick building on top of a reinforced concrete base structure. There are three sluice gates in the gate house. The gates are located at the bottom of the dam at elevation 14 feet below the crest of the spillway. They are equipped with rising-stems, 2-speed geared operators, for manual operation. Two of the gates are 60" x 42" and lead directly into the downstream channel (Wanaque River). The third sluice gate is 42" x 42" and was originally intended to control the flow to a penstock 5 feet in diameter and approximately 12,000 feet long, which was installed to supply water to a private manufacturing company. A concrete surge chamber for the penstock is located 60 feet downstream from the sluice gate.

Automatic devices in the gate house are intended to control the outlet flow. A weir and staff gage are provided in the downstream channel. An U.S.G.S. Gage Station is also provided at the weir. In addition, a float-well and level recording device are installed in the gate-house.

b. Location

Greenwood Lake Dam is located in the Township of West Millford, Passaic County, New Jersey. It is accessible by means of a local road which connects to East Shore Road.

c. Size and Hazard Classification

Greenwood Lake Dam has a structural height of 17 feet and a reservoir storage of 20,490 acre-feet. Since it's storage lies in the range 1,000 to 50,000 acre feet, it is classified in the dam size category as being of "intermediate" size. A hazard potential classification of "significant" has been assigned to the dam on the basis that failure would result in limited property damage and in the loss of a few lives. The property in the greatest potential danger is East Shore Road and Route 511. Up to twenty houses exist at Hewitt, about 2½ miles downstream, but only one or two of these are likely to be affected by discharge from Greenwood Lake.

Wanaque Reservoir is located about five miles downstream from the dam. Overtopping and possible breach of the dam will cause a rise in stage at this reservoir, but detailed investigation of this is outside the scope of a Phase I report. It should be treated in the more detailed hydrologic and hydraulic analysis recommended.

d. Ownership

Greenwood Lake Dam is owned by the State of New Jersey.

Bureau of Parks
Trenton, New Jersey 08625
(609) 292-4853

ATT: Mr. John Garcia, Supervisor Planning & Design

Local Authority
Ringwood State Park
(201) 962-7031

ATT: Mr. Bart Wallin, Assistant Ranger

f. Design and Construction History

Drawings on microfiche at the New Jersey Department of Environmental Protection indicate that the existing dam was built over and around an original masonry dam. The drawings of the existing structure and construction details are available on microfiche from NJDEP. According to available correspondence, it appears that the dam construction started in the second half of 1927, and was completed in the first half of 1928. No modifications are known to have been made since then.

g. Normal Operating Procedures

The discharge from the lake is over 2 unregulated spillways and it is allowed to naturally balance with inflow to the lake. An Assistant Ranger of Ringwood State Park has day-to-day control of the dam and he keeps the keys to the locked sluice gates. There is a contractual obligation on the State Park to provide a minimum flow at all times to Wanaque Reservoir downstream, and a U.S.G.S. Gaging Station records this flow, to ensure that it is adequate. When normal spillway flow is not adequate, the low-level sluices are opened. The lake is never normally lowered, and no regular maintenance is known to take place.

1.3 Pertinent Data

a. Drainage Area	27.1 square miles
b. Discharge at Dam Site	
Maximum known flood at dam site:	2 feet above spillway. (Discharge not recorded)
Ungated spillway capacity at elevation of top of dam:	3,089 cfs (elev. 639.1')
Total spillway capacity at maximum pool elevation:	6,161 cfs (elev. 640.8')
c. Elevation (feet above MSL)	
Top of dam:	639.1
Recreation pool:	635.7
Spillway crest:	635.5
Maximum pool design surcharge (SDF):	640.8
Streambed at centerline of dam:	621
Maximum tailwater:	627 (estimate)
d. Reservoir	
Length of maximum pool:	37,000 ± feet (estimate)
Length of recreation pool:	35,000 ± feet (estimate)
e. Storage (acre-feet)	
Recreation pool:	13,269
Top of dam:	20,490
Maximum pool:	24,556
f. Reservoir Surface (acres)	
Top of dam:	2,000 (estimated)
Spillway crest:	1,733

g. Dam

Type:	Complex reinforced concrete gravity structure.
Length (overall):	approx. 270'
Height:	17'
Top width:	2'

h. Diversion and Regulating Tunnel

N/A

i. Spillway

Type:	Two ungated concrete ogees with gate house in the center.
Length of weir:	120' (net length)
Crest elevation:	635.52' MSL
Gates:	None
U/S Channel:	None
D/S Channel:	After the spillway, Wanaque River.

j. Regulating Outlets

Low-level outlet:	Two 60" x 42" sluice gates.
Controls:	Hand operated geared stems.
Emergency gate:	None
Other outlet:	5' ø penstock.

SECTION 2: ENGINEERING DATA

2.1 Design

Drawings for the dam and spillway structures were available in the files of the New Jersey Department of Environmental Protection. No design computations were available, but some basic dimensions, flow capacities and characteristics are available on the dam construction bid documents date August 18, 1927.

2.2 Construction

The dam was constructed in 1927-28. Engineering data on the construction of the dam is limited to progress reports and an Engineer's description.

2.3 Operation

Records of daily flows are kept by the U.S.G.S.

2.4 Evaluation

a. Availability

The availability of engineering data is fair. The drawings illustrating the plan, sections and topography of the dam, can be obtained from the New Jersey Department of Environmental Protection. Correspondence and basic engineering data are on microfiche, also at the NJDEP.

b. Adequacy

The engineering data available (hydrologic and topographic data of the area) was adequate to perform hydrologic and hydraulic computations, although the depth of the lake is not known. A preliminary assessment of the dam could be made with the data obtained in the field, but there was not sufficient data to perform a computation of the dam's stability.

c. Validity

The stated drawings were found by inspection and by limited measurement in the field to be valid, except that the datum employed is not MSL datum.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The visual inspection made of Greenwood Lake Dam revealed that the dam and spillways were in serviceable condition, but that a regular program of inspection and repair is required to maintain its serviceability.

b. Dam

Greenwood Lake Dam has rock abutments and consists of 3 components which can be classified as appurtenant structures. All component structures are of reinforced concrete, (except for part of the gate house which has brick walls) and appear to be basically sound. The rock abutments were found to have no obvious deficiencies or weakness.

c. Appurtenant Structures

1. Left Spillway

The lake level at the time of inspection was above the spillway crest. The concrete ogee and discharge channel were submerged and could not be inspected in detail, but appeared to exhibit only minor surface deterioration. The flow over the crest appeared to be smooth, indicating that the horizontal alignment is good. There is a possibility that vertical monolith joints have been eroded. This is not considered to be a present hazard, but should be investigated. Vertical alignment of the crest appeared to be satisfactory.

2. Right Spillway

The right spillway consists of 3 weirs, each 10 feet wide. The weir crests were also under water and could not be inspected in detail, but flow was smooth. The exposed parts of the right abutment and wingwalls as well as the concrete walls separating the weirs show minor cracks and heavy spalling in some areas, principally at the water line.

3. Gatehouse

The gatehouse concrete foundation has undergone surface erosion up to 4" deep at the water line. A long horizontal crack was noted, but no dislocation has resulted. The condition of the upper, brick-built, portion is generally good, but the access door to the upstream platform is jammed shut.

4. Low-level Outlets

The low-level outlet gates were submerged and not accessible for inspection. However, the 2 main sluice gates which control the direct flow to the Wanaque River, were found to be in good working order and operated satisfactorily, at the time of the inspection.

The third sluice gate which originally controlled the flow to the 5' diameter penstock, had not been in use for many years.

From information available, it appears that the gate is not operable. A concrete surge chamber which was installed downstream in the penstock is still in place. The penstock was originally installed to supply water to a private manufacturing company. It could not be determined whether the full length of the original 12,000 feet of penstock is still in place.

5. Bridges

The superstructure of the foot-bridge over the right spillway appears to be in sound condition. No appreciable damage was detectable. The supporting piers, however, as well as the abutment and wingwalls, show cracking, surface spalling and erosion at the water line.

6. Trash Screens

All protective trash interceptor screens in front of the sluice gates were not in place during inspection. Some had been removed from the guide slots and stored in the gate house. The lifting gantry mechanism was rusted.

d. Reservoir Area

The lake perimeter is bounded by steep to moderate slopes which are wooded. Extensive residential and recreational development was evident all around the lake. There were no apparent indications of instability of slopes. Sedimentation could be observed at the lake discharge on the right side, but it is not reported to be a problem.

e. Downstream Channel

Below the spillways, the flow enters a stilling basin of indeterminate depth, but flow is not turbulent.

The stream channel is well defined with a rocky bottom. A few fallen trees are obstructing flow. Some man-made, low barriers of stone were seen in the stream, increasing depth locally.

Banks are steeply sloped (1H:1V) initially, falling back to 3H:1V or flat. Banks are mainly of rock, tree-covered, and appear stable.

Further downstream, a weir and staff gage as well as a U.S.G.S. Gaging Station are installed to monitor the flow.

A point of seepage was noted on the right bank, about 60 feet downstream of the dam. The flow rate was estimated at 2-3 cu. ft./sec. and slight artesian flow was noted. It should be noted that a heavy rain occurred in the area several hours earlier.

The downstream channel leads into the Wanaque Reservoir, about 5 miles below the dam.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Greenwood Lake Dam is used to impound water for recreation activities. The policy is to maintain a nearly constant lake level close to the elevation of the spillway crest. The lake level is maintained by unregulated discharge over the spillway. In the event of the flow downstream falling below a minimum amount (as described in Section 1.2.g) the low-level sluices are opened by the Assistant Ranger of Ringwood State Park to maintain a minimum flow. The lake is not otherwise lowered.

4.2 Maintenance of the Dam

The dam is maintained by the New Jersey Bureau of Parks. There is no formal program of regular inspection and maintenance of the structures. No records of work done at the dam and lake are kept.

4.3 Maintenance of Operating Facilities

The operating facilities consist of 3 sluice gates. Sufficient maintenance has been carried out to insure present operability of 2 sluice gates only.

4.4 Evaluation

The dam and reservoir appear to be maintained in a serviceable condition, although the concrete has been allowed to deteriorate without repair. Such repairs as recommended must be undertaken to prevent accelerated deterioration from ice.

Existing operational procedures have proved satisfactory for many years, although the need to maintain the minimum flow in summer is reported to draw complaints from the lake users.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The drainage area above Greenwood Lake Dam is approximately 27.1 square miles. A drainage map of the watershed of the dam site is presented on Plate 1, Appendix D.

The topography within the basin is moderately to steeply sloped. Elevations range from approximately 1,400 feet above MSL at the east end of the watershed to about 640 feet at the dam site. Land use patterns within the watershed are mostly woodland with concentrated residential development about the lake area.

The evaluation of the hydraulic and hydrologic features of the dam and lake was based on criteria set forth in the Corps Guidelines and additional guidance provided by the Philadelphia District, Corps of Engineers. The Spillway Design Flood for the dam falls in a range of 1/2 PMF to PMF. In this case, the lower end of the range, 1/2 PMF, is chosen since the dam height is at the middle to lower range of the size category.

The probable maximum flood (PMF) was calculated from the probable maximum precipatation using *Hydrometeorological Report No. 33* with standard reduction factors.

The unit hydrograph was determined by Snyder's Method. Snyder's peaking coefficient Cp was specified by the COE as 0.62. The synthetic unit hydrograph was developed with the aid of the HEC1-DB program.

Initial and infiltration loss rates were applied to the Probable Maximum Precipitation to obtain rainfall excesses. The rainfall excesses were applied to the unit hydrograph to obtain the PMF and various ratios of PMF utilizing program HEC1-DB.

The SDF peak outflow calculated for the dam is 6,161 cfs. This value is derived from the 1/2 PMF, and results in overtopping of the dam, assuming that the lake was originally at the spillway crest elevation.

The stage-outflow relation for the spillway was determined from the geometry of the spillway and dam, utilizing HEC1-DB program.

The reservoir stage-storage capacity relationship was computed directly by the conic method, utilizing the HEC1-DB program. The conic method assumes that the reservoir capacity resembles a series of vertically stacked cones. The reservoir surface areas

at various elevations were measured by planimeter from a U.S.G.S. Quadrangle topographic map. Reservoir storage capacity included surcharge levels exceeding the top of the dam, and the spillway rating curve was based on the assumption that the dam remains intact during routing.

A breach analysis is not necessary for a "significant" hazard dam.

Drawdown calculations indicate that to empty the lake to an elevation of 621.5' MSL through the two low-level sluices would take 18 days, assuming a 2 cfs/square mile inflow. This is considered to be an excessive draw-down period, and provision of additional outlets should be considered.

b. Experience Data

Persons familiar with the lake recall the water level rising by up to 2 feet above spillway level after heavy rainfall. The down-stream water elevation rose by approximately 4 feet at this time. U.S.G.S. Gaging Station No. 01383500 is located about 600' down-stream, and records indicate a maximum rise in water level of about 6 feet above normal after a storm in 1955.

c. Visual Observation

The downstream channel is well defined between steep (1H:1V) banks below dam, with trees growing on the banks. Within 1,000 feet the banks become flatter. The first occupied buildings in the flood path are 2½ miles downstream at Hewitt, and the valley above this location has no development except for a road which is not heavily travelled. At Hewitt, it is estimated that only one or two buildings are in the flood-path. For this reason, the hazard potential is downgraded from "high" to "significant."

The slopes of the reservoir are moderate to steep and do not exhibit signs of instability. The drainage area is wooded, moderately to steeply sloped and developed for residential use around the lake.

d. Overtopping Potential

A storm of magnitude equivalent to the SDF would cause overtopping of the dam to a height of 1.67 feet. Computations indicate that the dam can pass approximately 31 percent of the PMF without overtopping the dam crest. Since one half the PMF is the Spillway Design Flood (SDF) for this dam, according to the Recommended Guidelines for Safety Inspection of Dams by the Corps of Engineers, the spillway capacity of the dam is assessed as "inadequate."

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation

All components of the structure appear to be in satisfactory condition with regard to stability, except for minor deficiencies which require further investigation. The superstructure of the gate house and of the approach bridge show no significant signs of deterioration. The substructures were partially visible, and show numerous cracks, spalling and scouring in the abutment and wingwalls and gateway walls. The spillways were completely submerged and not accessible for detailed visual inspection. However, there is a possibility of erosion in the spillways as implied in an inspection report (see Section 6.1.c). Therefore, further investigation is recommended.

In view of the existence of cracks, the right bridge abutment should be investigated for possible undermining. The seepages noted downstream require further investigation but are not thought to constitute a hazardous situation.

b. Design and Construction Data

No design computations were uncovered during the report preparation phase. No foundation soil or rock parameters are available for carrying out a conventional stability analysis of the structure. No construction data or specifications relating to the gate-house and spillway foundations are available for use in the stability analysis.

Some drawings for the spillway and gate house are available on microfiche in the files of the NJDEP.

c. Operating Records

No operating records are available relating to the stability of the dam. The dam has served satisfactorily since its construction in about 1927-28.

From correspondence records available on microfiche from NJDEP, it appears that an inspection of Greenwood Lake Dam after a severe flood in 1955 revealed the following:

The sluice gates were not opened in time before the flood and the reservoir level was not drawn down. This resulted in excessive spillway flow and flooding downstream. However, no structural damage to the dam was detected.

Another report on inspection after a flood in 1968 indicates that considerable damage was detected. The spillways and the gate outlets showed extensive spalling and exposure of coarse aggregate.

Significant cracking was also visible in the gate house walls, but it is doubtful if this damage was all caused by the flood.

d. Post-Construction Changes

No records of any alteration; repair work, or any other construction activity on the dam subsequent to the initial construction of the 1927/28 period are available.

e. Static Stability

A static stability analysis was not performed for Greenwood Lake Dam because the lack of data on which to base assumptions of material properties might produce misleading results. The static stability is considered, by inspection only, to be satisfactory.

f. Seismic Stability

The dam is located in Seismic Zone 1, as defined in Recommended Guidelines for Safety Inspection of Dams, prepared by the Corps of Engineers. In general, projects located in Seismic Zones 0, 1 and 2 may be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist. Since the last two conditions are considered to be satisfactory, seismic stability is not regarded as a problem on this dam.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The dam has been inspected visually and a review has been made of the available engineering data. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers for a Phase I report.

The safety of Greenwood Lake Dam is in question because the dam does not have adequate spillway capacity to pass the PMF or even one-half of the PMF without overtopping. Overtopping of the abutments carries with it the danger of possible progressive failure of the structures. The dam's present spillway capacity is about 31 percent of the PMF and is judged to be "inadequate."

No definitive statement pertaining to the safety of the structure can be made without acquisition of foundation material engineering properties.

Based on a cursory geological survey and a review of available pertinent literature it appears that the dam site contains mostly glacial fill overlying gneissic bedrock. The material appears to be sound as a structural foundation base, however, a detailed investigation is required to verify this.

b. Adequacy of Information

The information uncovered was adequate to perform hydrologic computations, although the depth of the lake is not known. The data was insufficient to perform a computation of the dam's stability. An assessment of the dam could be made by visual observation only.

c. Urgency

Carry out a more precise hydrologic and hydraulic analysis of the dam within six months, to determine the need and type of mitigating measures necessary. If required, conduct a study of the means of increasing spillway discharge capacity and develop alternative schemes for construction. This should include the installation of a tailwater gage.

Studies to determine the hydrologic and hydraulic ability of the bridge to withstand overtopping and of the gate house to withstand hydrostatic pressure should be undertaken by an engineer qualified in the design and construction of dams within six months.

The existing dam plans and drawings should be annotated and updated to form a coherent as-built set within a reasonable period of time.

The seepages noted on the right bank should be investigated within three months.

Tests to determine the engineering properties of the foundation material of the dam should be made within 6 months, and a stability analysis based on the findings should be made immediately upon acquisition of data.

All low-level sluice gates should be inspected by a diver within 12 months. The extent of erosion in the monolith joints should be investigated at the same time.

7.2 Remedial Measures

a. Alternatives for Increasing Spillway Capacity

Alternatives for increasing spillway capacity are as follows:

1. Raise the dam, abutment and bridge, thus permitting a higher discharge to pass over the spillway and reducing the possibility of overtopping. However, it must be kept in mind that the downstream channel capacity is already less than the spillway capacity.

2. Lower the main spillway crest elevation.

3. A combination of any of the above alternatives.

b. Other Remedial Measures

1. Repair all spalled, eroded and cracked concrete with epoxy cement within 6 months.

2. Based on the results of the divers inspection, repair low-level sluices as necessary.

c. Recommendations

The following additional action is recommended.

1. Replace the trash screens, restore the lifting gantry and re-open access to the rear gate-house platform within a reasonable period of time.

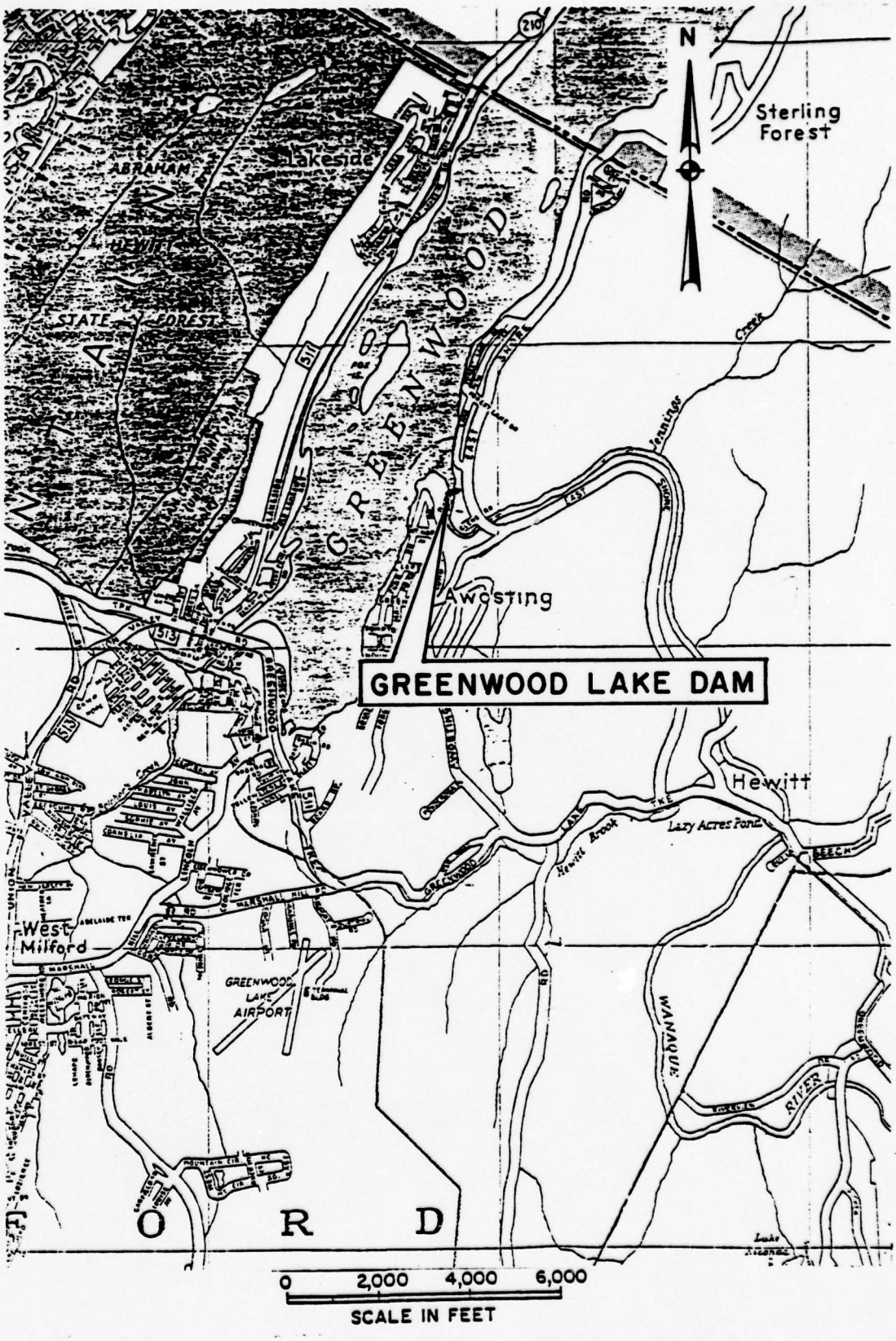
2. Establish a flood warning system for the downstream communities within three months.

3. Consider providing additional low-level discharge facilities.

d. O & M Procedures

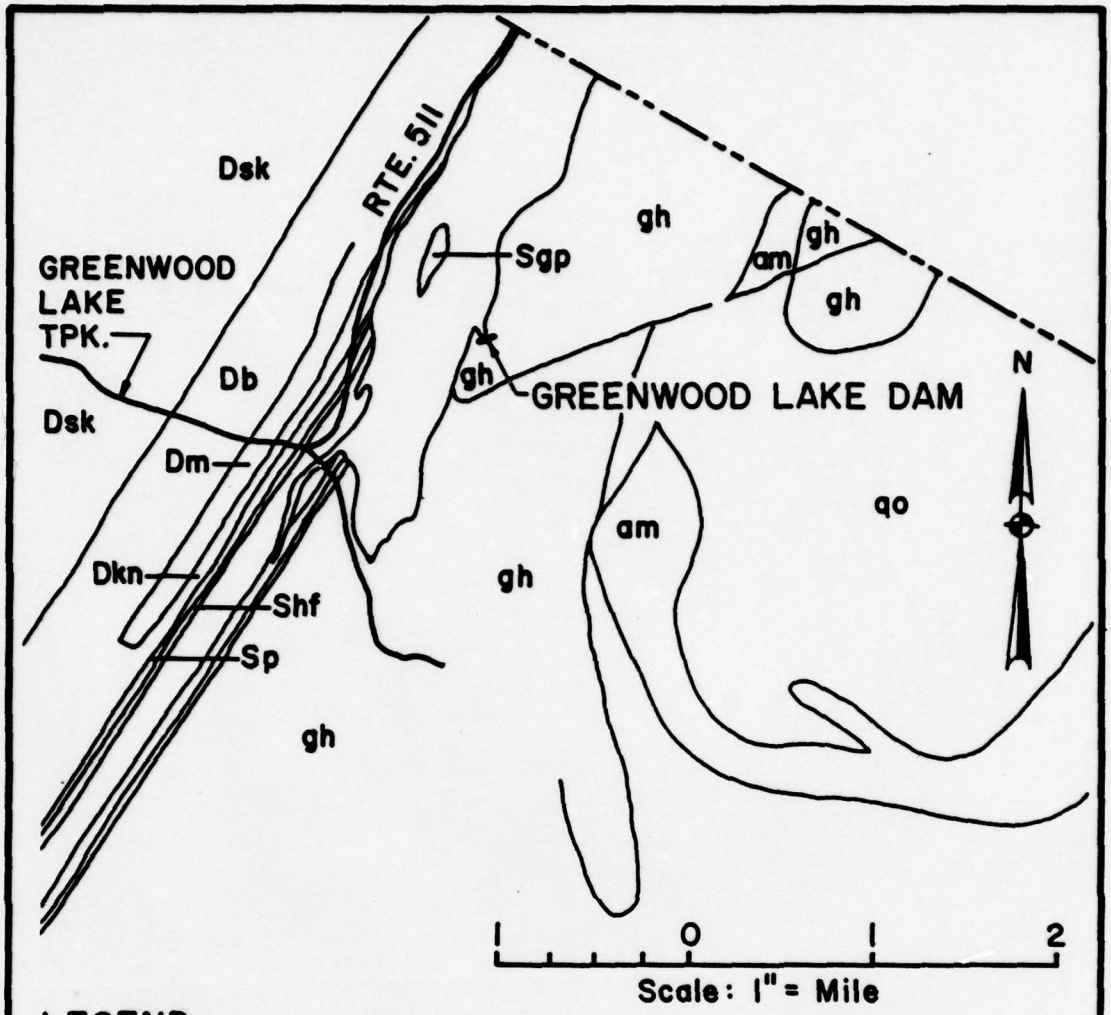
A formalized program of annual inspections of the dam by an engineer experienced in the design and construction of dams should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be read during severe rain storms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance visits to the dam, the lake and the outlet passages. Movement and settlement of the structures should be monitored regularly by means of surveying monuments. All seepage should be monitored.

PLATES



VICINITY MAP

PLATE 1



LEGEND

PRE-CAMBRIAN

gh	Hornblende Granite & Gneiss
am	Amphibolite
qo	Quartz - Oligoclase - Gneiss

SILURIAN

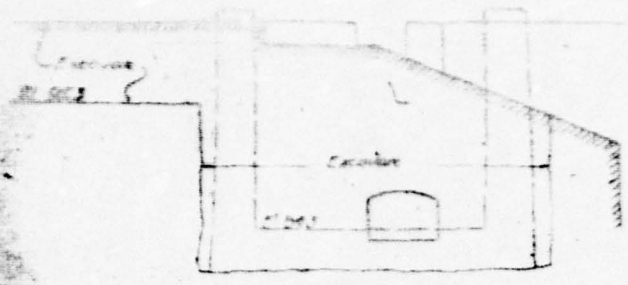
Shf	High Falls Formation (Sandstone and Shale)
Sgp	Green Pond Conglomerate
Sp	Poxono Island Formation

DEVONIAN

Db	Bellvale Sandstone
Dm	Marcellus Shale
Dkn	Kanouse Sandstone
Dsk	Skunnemunk Conglomerate

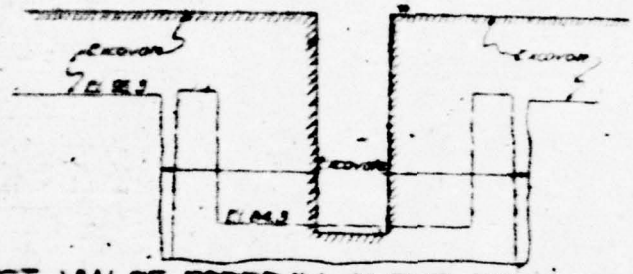
GEOLOGIC MAP
GREENWOOD LAKE DAM

PLATE 2

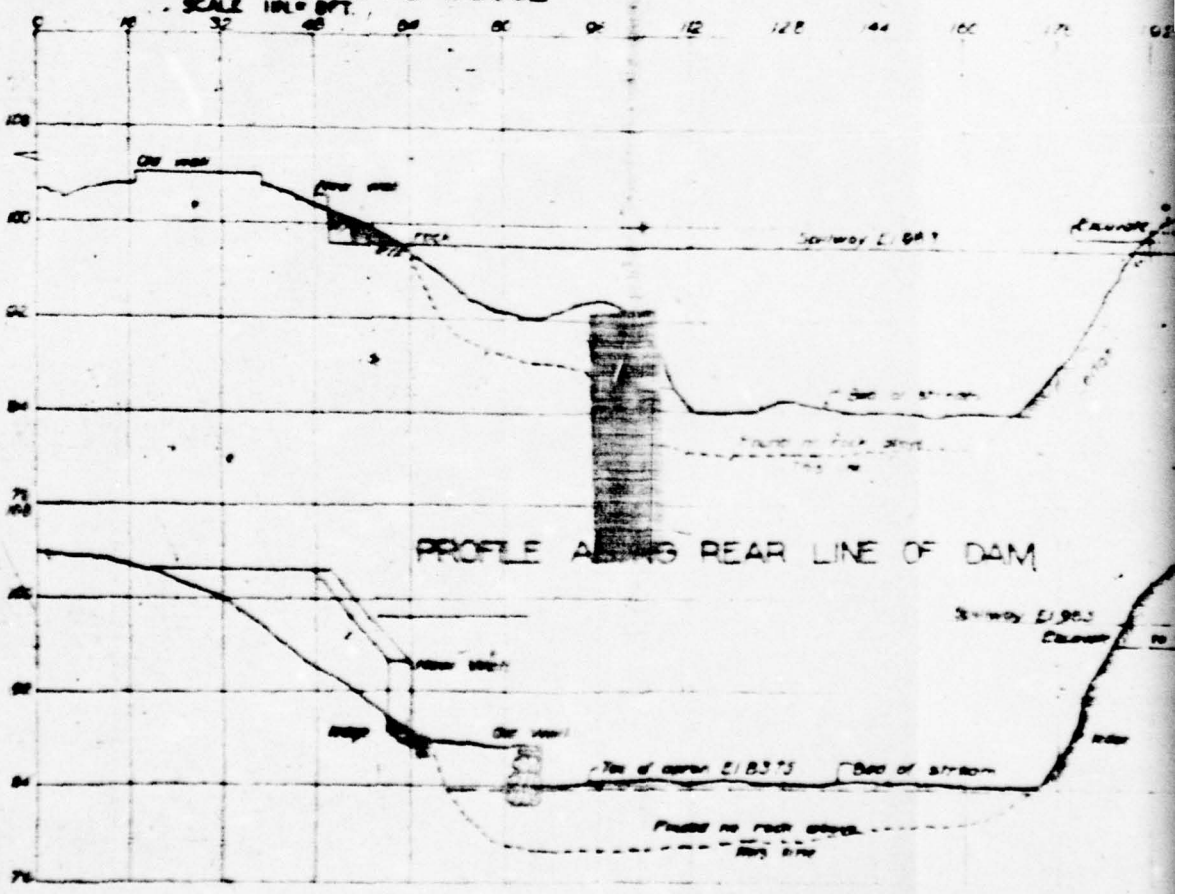


SECT. TU OF FOREBAY 10 FT. NW FRO
AND PARALLEL WITH NEW GATE HO
NEW WORK SHOWN IN BROKEN LINES
SCALE 1 IN = 8 FT.

SECT. XY OF FOREBAY 16
PARALLEL WITH REAR
COFFER DAM MAY BE AT THIS SECTION
LAKE TO BE DRAWN OFF TO ELEV. 92
SCALE 1 IN = 8FT.



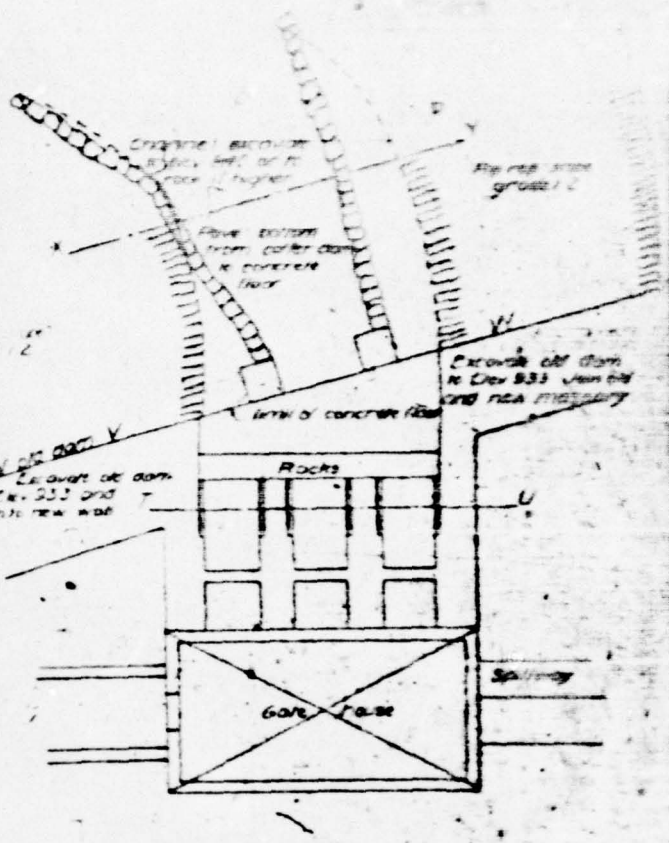
SECT. VW OF FOREBAY ALONG REAR LINE OF
OLD DAM THROUGH OLD GATE HOUSE
SCALE 1 IN = 8FT.



PROFILE ALONG REAR LINE OF DAM

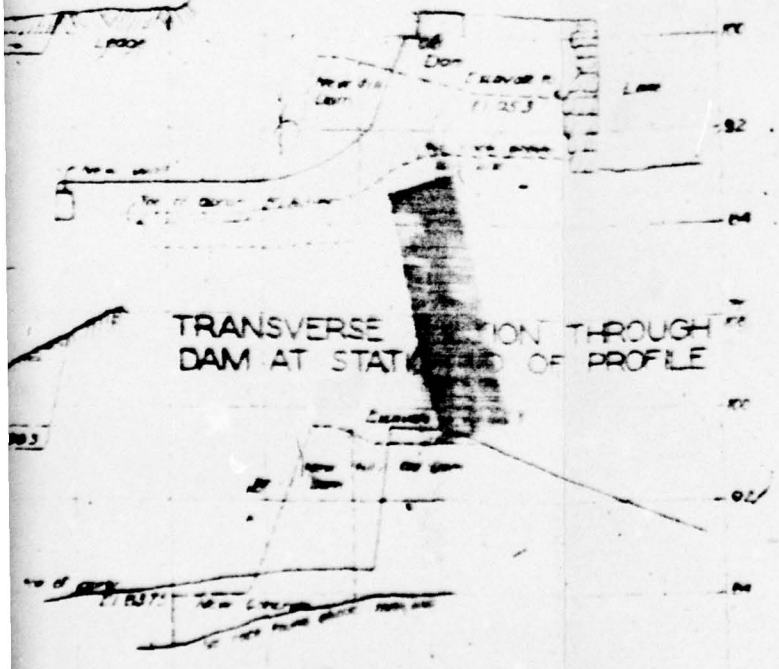
PROFILE ON LINE OF TOE OF APRON

T FROM AND
OF OLD DAM
WHILE BUILDING GATE HOUSE



PLAN OF GATEHOUSE AND FOREBAY SHOWING CONNECTION WITH OLD DAM

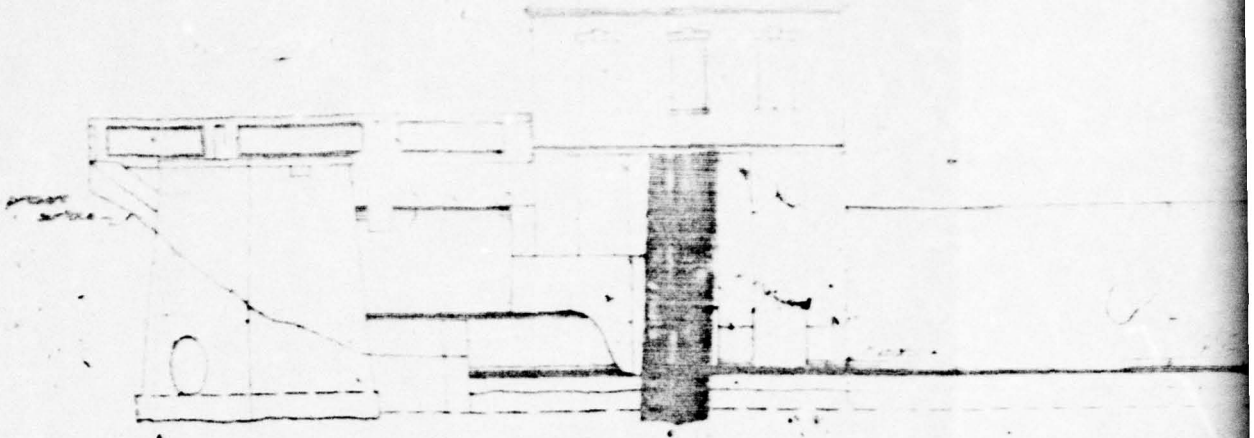
SCALE 1IN = 8FT



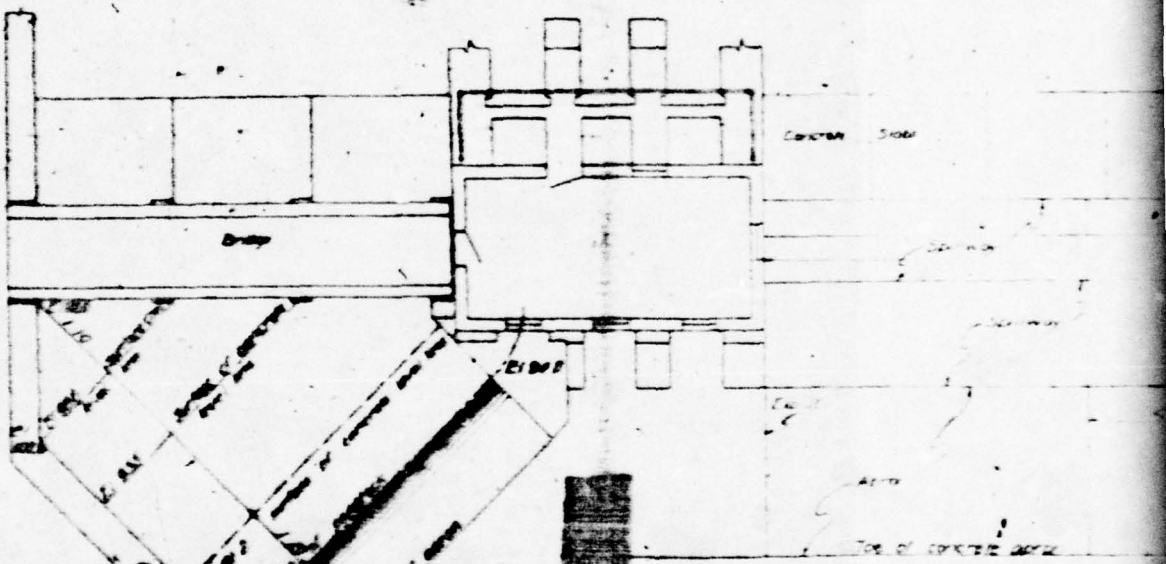
TRANSVERSE SECTION THROUGH DAM AT STATION OF PROFILE

TRANSVERSE SECTION THROUGH DAM AT STATION 128 OF PROFILE

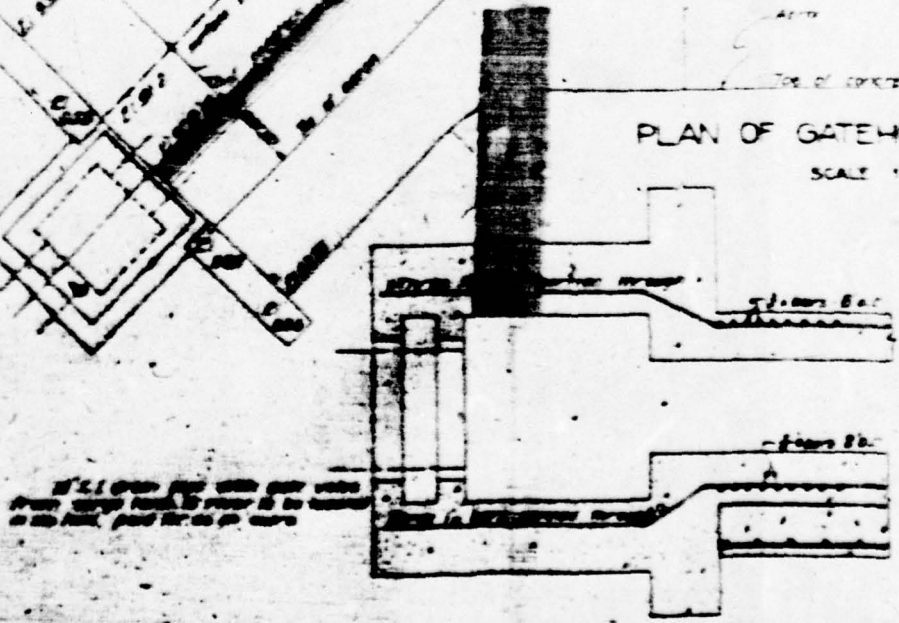
PLATE 3



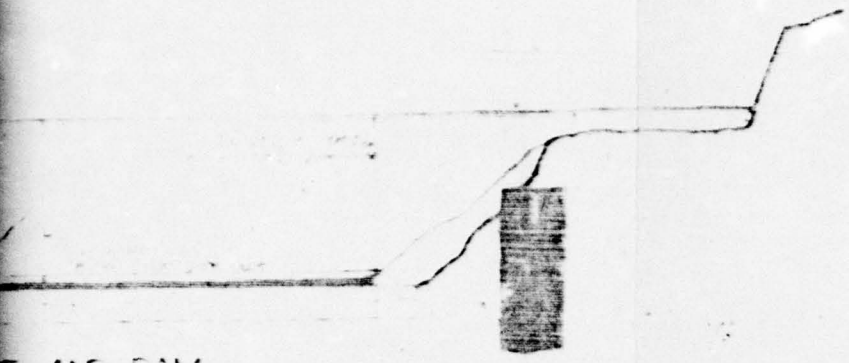
DOWNSTREAM ELEVATION OF GATEHOUSE AND



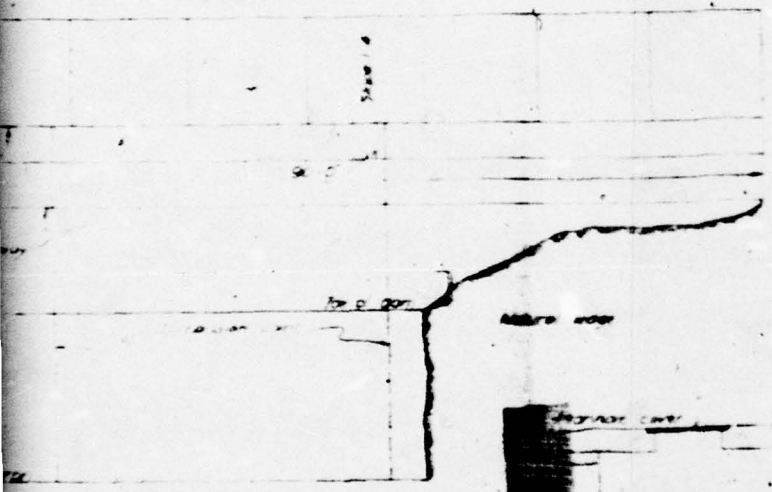
PLAN OF GATEHOUSE AND



HOR SECT. OF SURGE TANK AT ℄
OF PENSTOCK

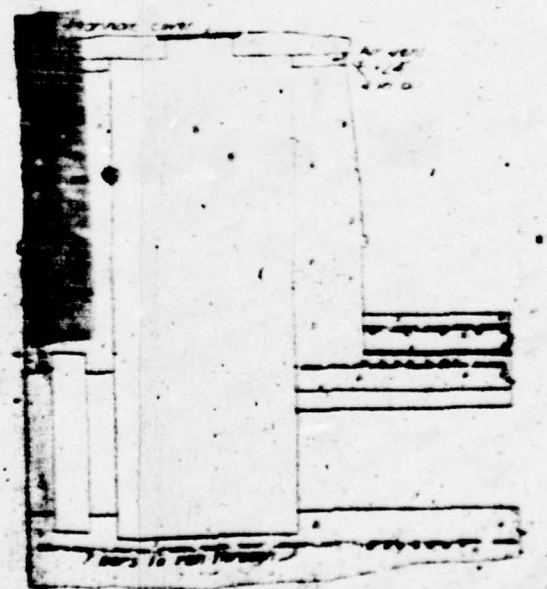


E AND DAM



NOTE
CUT ALL EXPOSED EDGES WITH 2"×2" CHAMFILLET ON CONCRETE

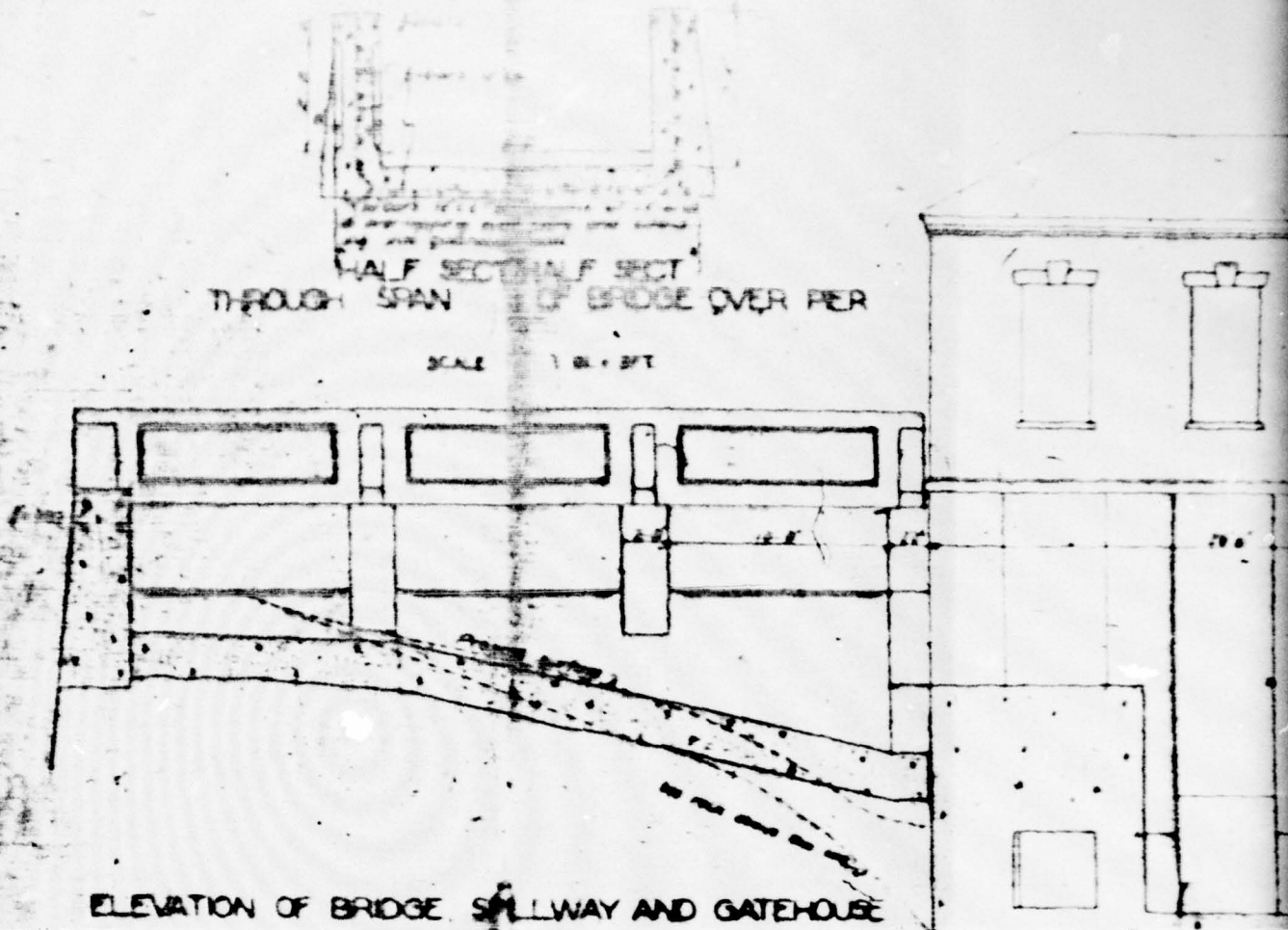
E AND DAM



VERT SECT OF SURGE TANK AT END OF PENSTOCK

SCALE 1/8"=1'-0"

PLATE 4

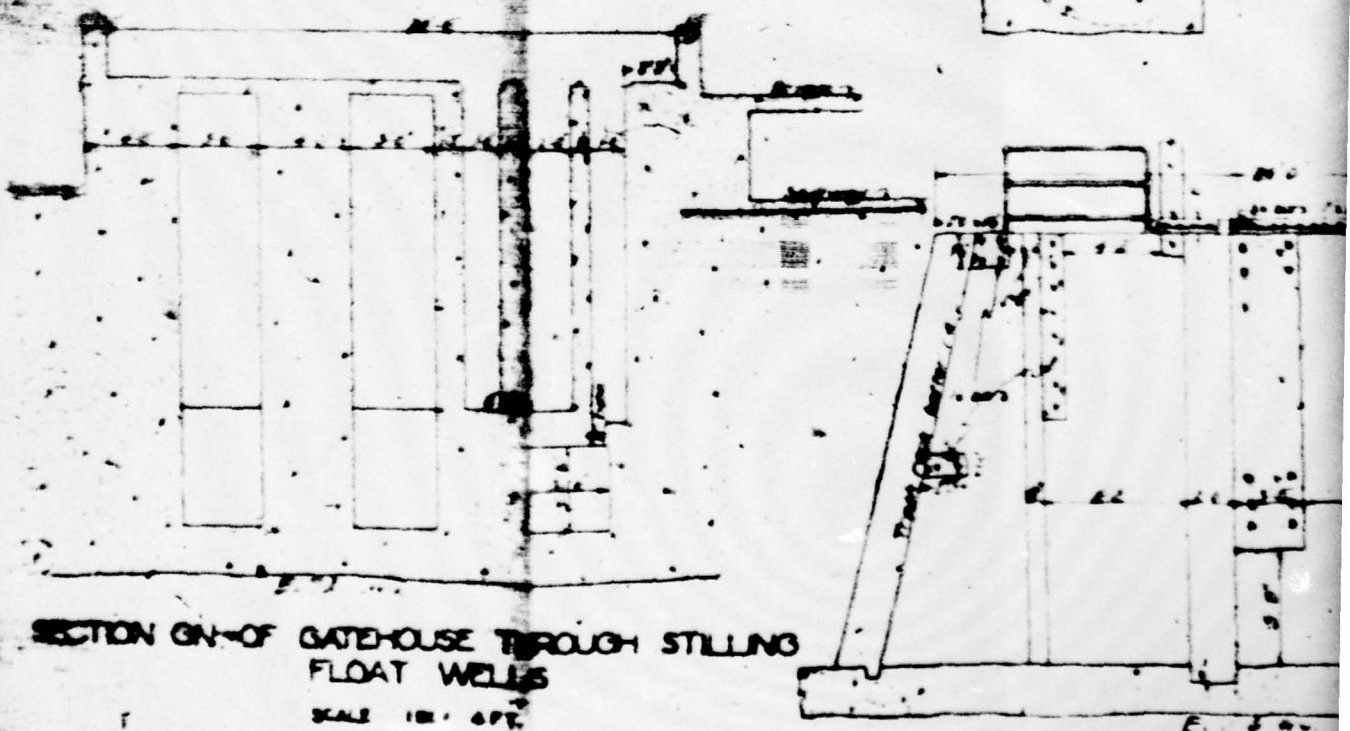


HALF SECTION OF SECT
THROUGH SPAN OF BRIDGE OVER PIER

SCALE 1 IN. = 8FT

ELEVATION OF BRIDGE SPILLWAY AND GATEHOUSE

SCALE 1 IN. = 8 FT

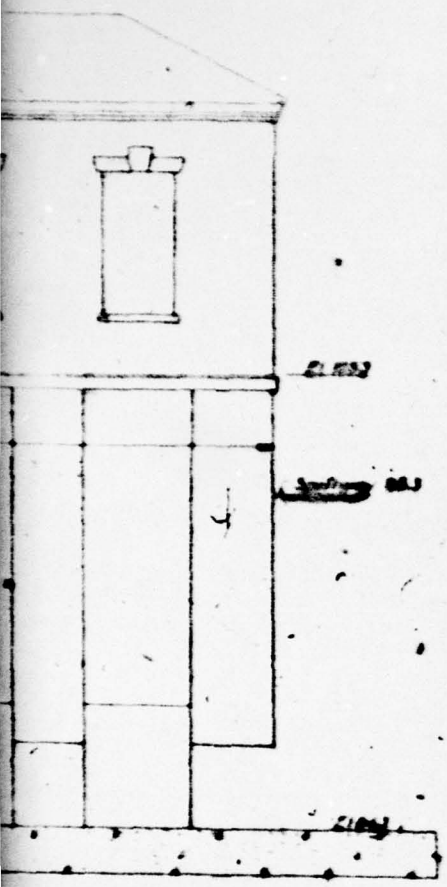


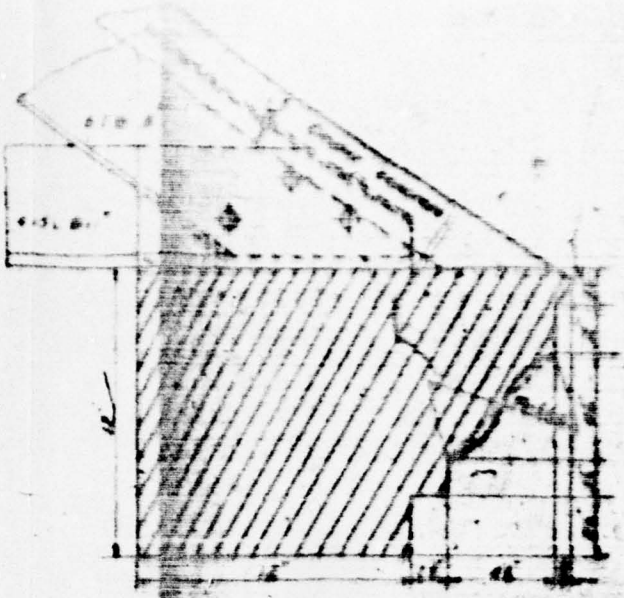
SECTION ON C OF GATEHOUSE THROUGH STILLING
FLOAT WELLS

SCALE 1 IN. = 6FT

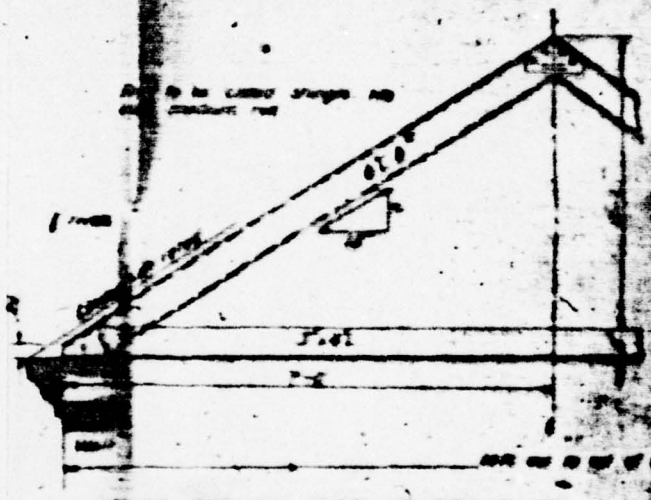
SECTION THROUGH CENTER

SCALE 1 IN

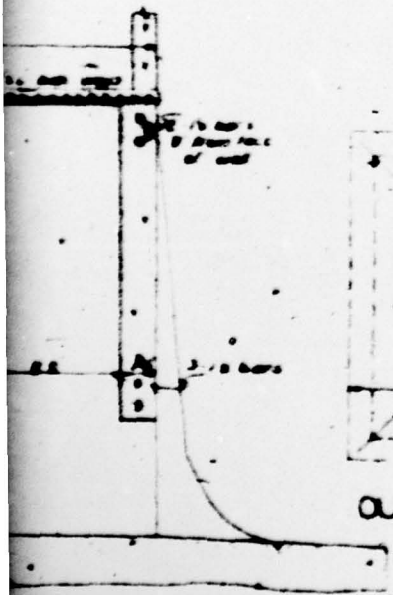




DETAIL OF INDIANA LIMESTONE CORNICE



ROOF TRUSS FOR GATE-HOUSE



OF MIDDLE SLUICE GATE

OUTLINE OF IRONWORK FOR ROOF

PLATE 5

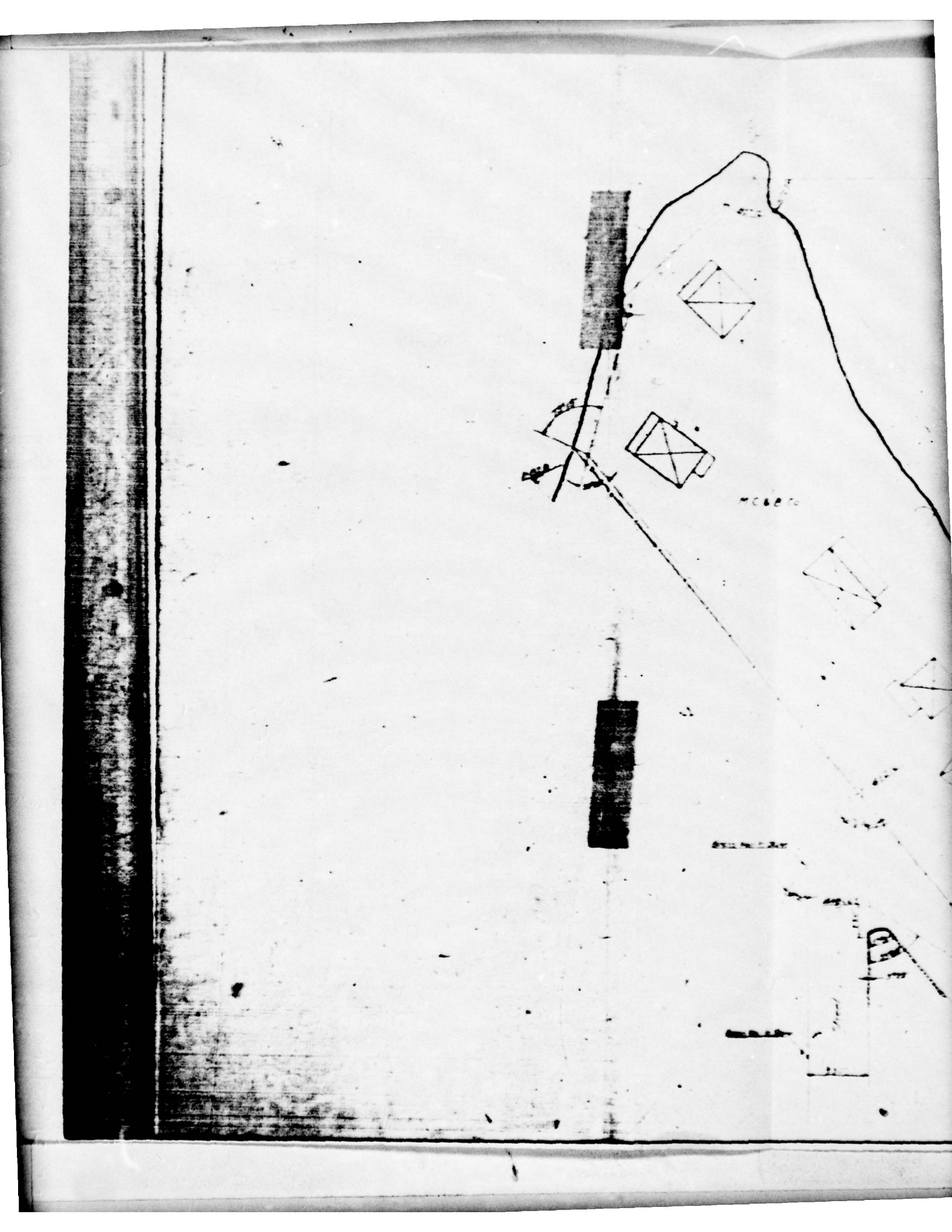
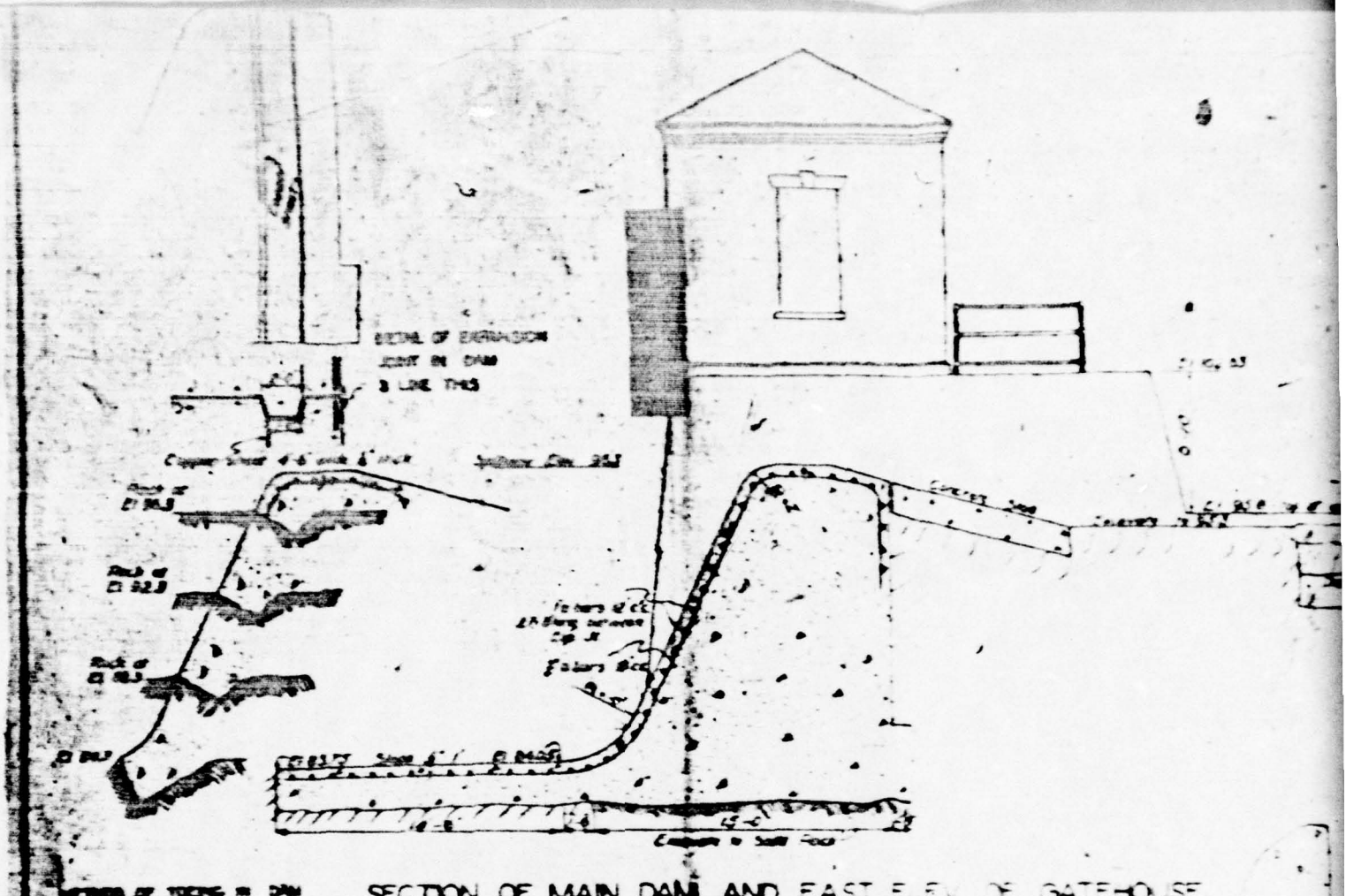
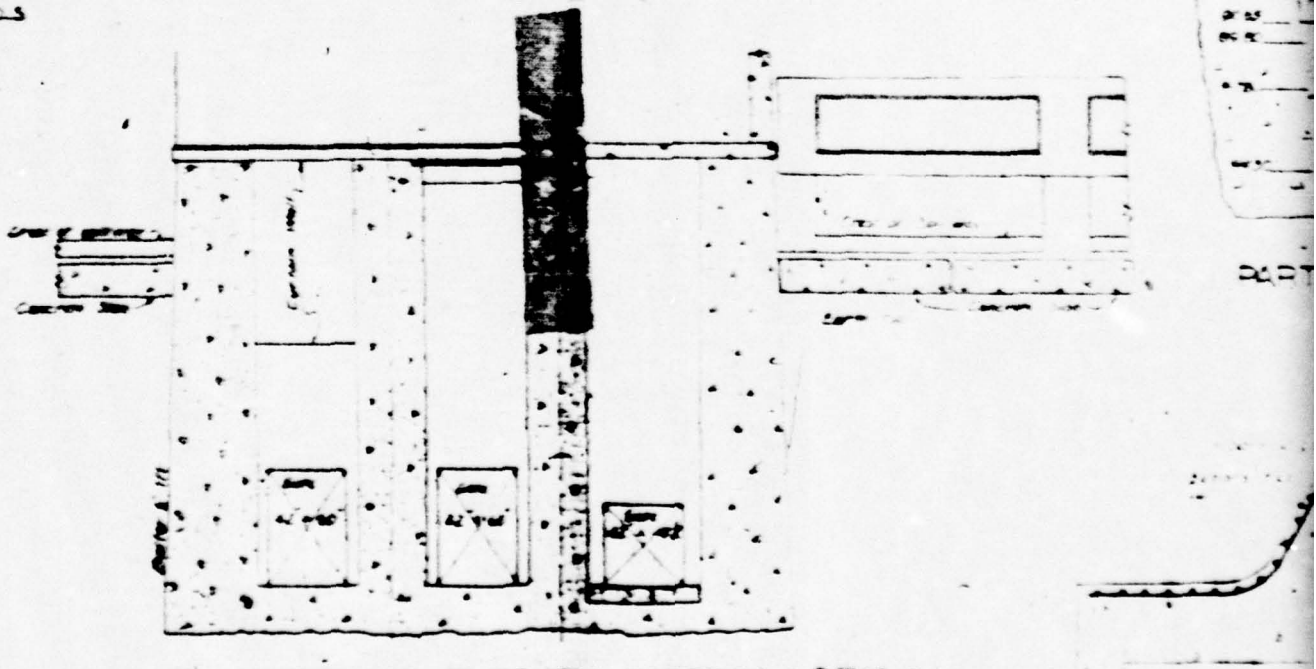


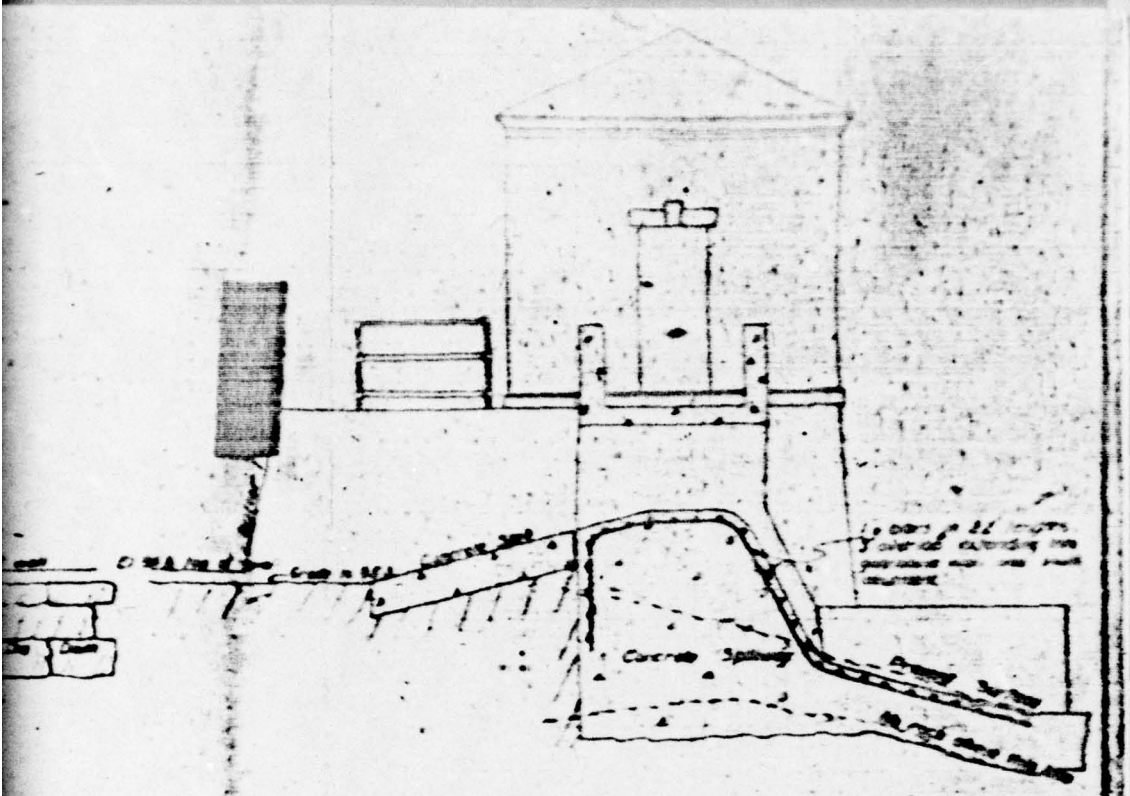
PLATE 6



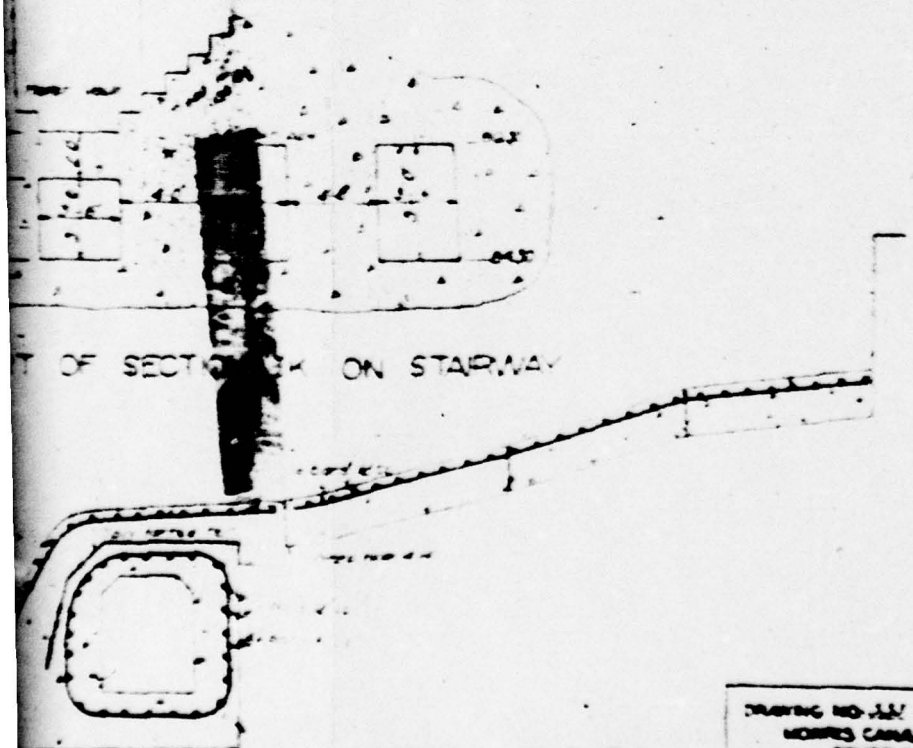
SECTION OF MAIN DAM AND EAST ELEV. OF GATEHOUSE



BROKEN SECTION CD THROUGH FOREBAY LOOKING TOWARD GATE HOUSE



WEST ELEV OF GATEHOUSE AND SECTION THROUGH SPILLWAY AND BRIDGE 10 FEET WEST OF GATEHOUSE



T OF SECTION L-M ON STAIRWAY

SECTION L-M THROUGH PENSTOCK AND SPILLWAY

DRAWING NO. 3-W SECTION FOR THE MORRIS CANAL & BANKING CO. DOVER N.J. OFFICE

DETAILS

DATE 4/15 SCALE 1"=1'

CONSULTING & DIRECTING ENGR.

PLOTTED BY

TRACED BY

PLATE 7

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION, MAINTENANCE DATA

CHECK LIST
VISUAL INSPECTION

PHASE I

Name of Dam Greenwood Lake County Passaic State New Jersey Coordinators NJDEP

Date(s) Inspection May 9, May 31 June 3, 1979 Weather Sunny Temperature 80°

Pool elevation at Time of Inspection 635.7' M.S.L. Tailwater at time of Inspection 621.5' M.S.L.

Inspection Personnel:

May 9, 1979	May 31, 1979	June 3, 1979
H. King C. Chin E. Koo	W. Flynn (Mechanical)	W. Jones (Geologist) C. Chin

Owner/Representative:

None Attended.	Bart Wallin (Asst. Ranger)	None attended.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Cracks visible along bridge abutments and wingwalls. Severe spalling and cracking at the water line on bridge piers and on gatehouse foundation.	Repair with epoxy cement.
STRUCTURAL CRACKING	Deep cracks along gatehouse foundation, up to 1/2 the distance across (up to second column).	Epoxy grout under pressure.
VERTICAL & HORIZONTAL ALIGNMENT	No misalignment was observed.	
MONOLITH JOINTS	Possible deep gouging of vertical monolith joints in left spillway. Flow obstructing inspection, and thus it could not be confirmed that gouging has occurred.	Does not appear to be serious to overall stability. Investigate further and repair as necessary.
CONSTRUCTION JOINTS	No deficiences.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SEEPAGE OR LEAKAGE	Minor leakage detected downstream at toe of wingwall. Twenty yards downstream on the right bank, a seepage of 3 cfs was found.	Further observation and monitoring recommended.
STRUCTURE TO ABUTMENT/ EMBANKMENT JUNCTIONS	No deficiences visible. Dam abuts onto solid rock on both sides.	
DRAINS	None observed.	
WATER PASSAGES	42" x 42" sluice gate at invert 621.5' leading to 5' diameter penstock, (12,000 feet long) originally supplying water to the Lingwood Co. Hexagonal surge tank to right of right wingwall.	Sluice gate is not operable and a solid concrete plug should be placed in the penstock.
FOUNDATIONS	Supported on glacial till overlying gneissic rock.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONCRETE WEIR	Both weirs showed good alignment and only minor cracking and surface deterioration. Weirs are of ogee section.	Water flow was light but visibility of weir was limited.
APPROACH CHANNEL	Tree trunk lodged at approach to left spillway. Bottom is very shallow in the right spillway approach.	
DISCHARGE CHANNEL	The right spillway apron contained some debris. Some cracking and spalling at wingwalls and abutments in discharge channel were noted.	Debris not affecting discharge. Repair concrete.
BRIDGE AND PIERS	Superstructure of bridge in good condition. Piers, abutments and wingwalls show spalling, cracking and erosion.	Restore concrete by patching with epoxy mortar.
FOUNDATIONS	Not accessible.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CRACKING & SPALLING OF CONCRETE SURFACES IN STILLING BASIN	Stilling basin was partially submerged, but visible portion was sound.	
INTAKE STRUCTURE	Submerged. Some trash screens have been removed and were stored in the gate house.	Reinstall trash screens.
OUTLET STRUCTURE	Two 42" x 60" low-level sluice gates. Passages discharge directly into downstream channel. Right sluice gate was leaking approximately 100 gpm at the inspection.	
OUTLET FACILITIES	The sluice gates have 2-speed, geared manual operators which were found to be in good working order. The gates are kept locked and the keys are retained by Ringwood State Park. One gate-house is likewise locked.	
EMERGENCY GATE	None.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
MONUMENTATION/SURVEYS		
None.		Establish a MSL benchmark at the dam.
OBSERVATION WELLS		
None.		
WEIRS		
A staff-gage for direct reading of the lake level is fixed to the right wall of the gate-house, just above the right weir.		Gage was legible but did not read to MSL.
PIEZOMETERS		
None.		
OTHERS		
1. A U.S.G.S. Gaging Station. 600 feet downstream, monitors the water flow in the channel. 2. A float-well and recording device is provided in the gate-house for periodically measuring lake levels.		

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SLOPES	Slopes around lake are steep to moderate and are mostly tree-covered, with suburban development.	
SEDIMENTATION	Silting was noted at the approach to the right spillway, but it does not appear to be a significant problem. Otherwise, sedimentation was reported to be light.	
USE	Greenwood Lake is a recreational facility under the control of Ringwood State Park. However, there is a legal obligation on the part of the Park to supply a minimum flow at all times to Wanaque Reservoir downstream.	
SHORELINE BUILDINGS	Extensive development of houses and clubs around the shoreline, with numerous boating stages.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Well defined stream channel with a rocky bottom. A few fallen trees obstructing flow. Some man-made, low barriers of stone in the stream, increasing depth locally. U.S.G.S. gaging station and weir 600' downstream.	
SLOPES	Steeply sloped (1H:1V) initially, falling back to between 3H:1V and flat. Slopes are mainly of rock, tree-covered, and appear stable.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	More than 20 homes within 3 miles, but only one or two are in the flood path. The Wanaque River passes under and runs along-side two roads in this distance, which might be submerged in the event of SDF over the spillway or dam failure.	Recommended hazard potential downgraded to "significant."

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Available on microfiche, included.
REGIONAL VICINITY MAP	U.S.G.S. Quadrangle Sheet - Greenwood Lake, New York-New Jersey
CONSTRUCTION HISTORY	1927 - Construction Contract Drawings
TYPICAL SECTIONS OF DAM	Available on drawings (microfiche: NJDEP), included.
HYDROLOGIC/HYDRAULIC DATA	None available on microfiche.
OUTLETS - PLAN	On included drawing (from NJDEP Microfiche)
- DETAILS	On included drawing (from NJDEP Microfiche)
- CONSTRAINTS	On included drawing (from NJDEP Microfiche)
- DISCHARGE RATINGS	Not available.
RAINFALL/RESERVOIR RECORDS	Not available. (N.B. Refer to U.S.G.S. Records of Gaging Station No. 01383500 for water elevations in channel).

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
DESIGN REPORTS	Construction bid documents (NJDEP Microfiche).
GEOLOGY REPORTS	Some information on bedrock in Construction progress reports. (NJDEP Microfiche).
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available.
POST-CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	None.
SPILLWAY PLAN - SECTIONS - DETAILS	1927 - Contract drawings, included (from NJDEP Microfiche).

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
OPERATING EQUIPMENT PLANS AND DETAILS	On drawing (NJDEP Microfiche).
MONITORING SYSTEMS	Details of float-well in gate-house on drawing. No records available.
MODIFICATIONS	None on record.
HIGH POOL RECORDS	None on records. Verbally reported to have risen 2 feet above spillway crest.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	1968 by Nicholas Biocco, P.E. (NJDEP Microfiche).
PRIOR ACCIDENTS OF FAILURE OF DAM - DESCRIPTION - REPORTS	Reports on effect of floods in 1955 and 1968 available on microfiche from NJDEP.
MAINTENANCE OPERATION RECORDS	None available.

APPENDIX B

PHOTOGRAPHS

(Taken on May 9, 1979)

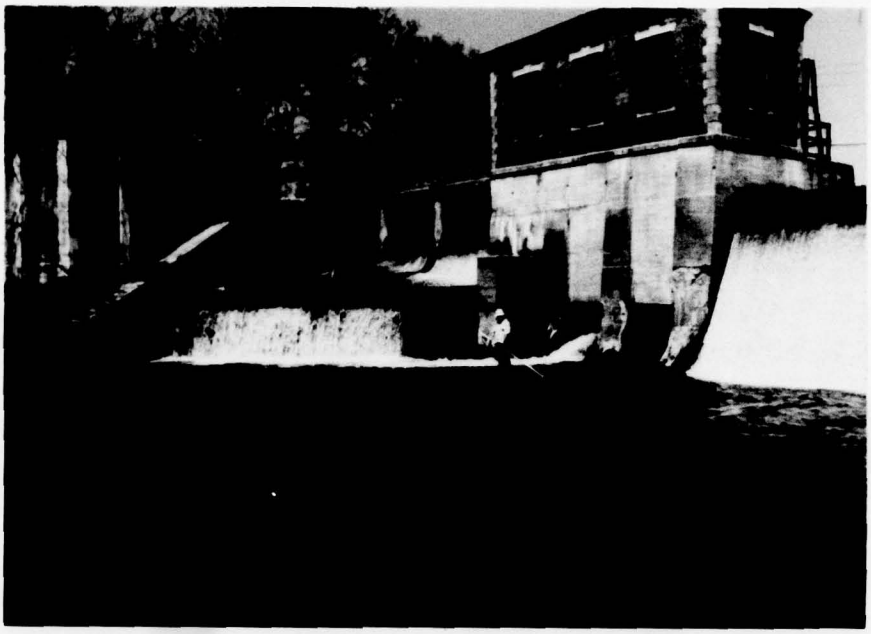


Photo No. 1 - Overall view of right side of dam from downstream. The right spillway, bridge structure, gate house and surge tank can be seen.

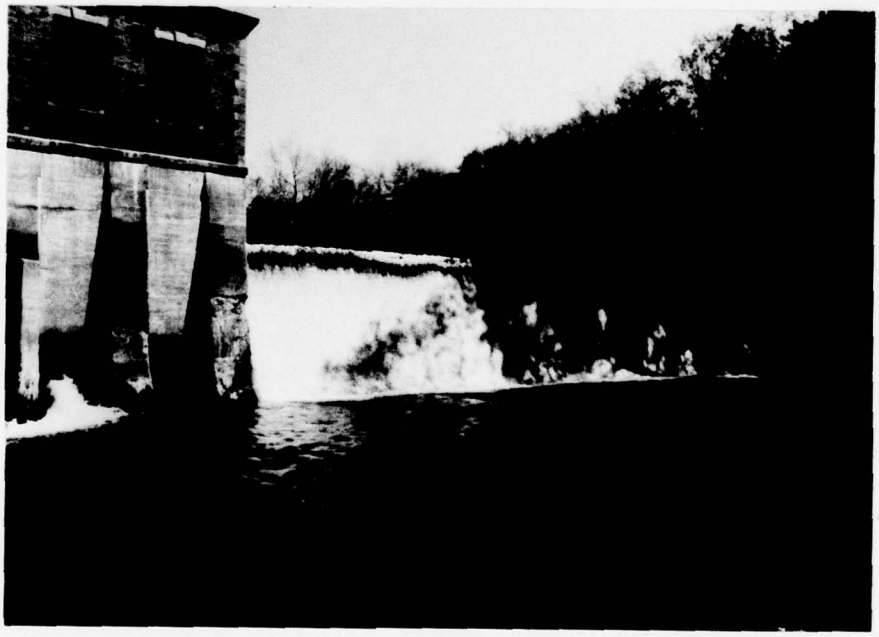


Photo No. 2 - Overall view of left side of dam from downstream.

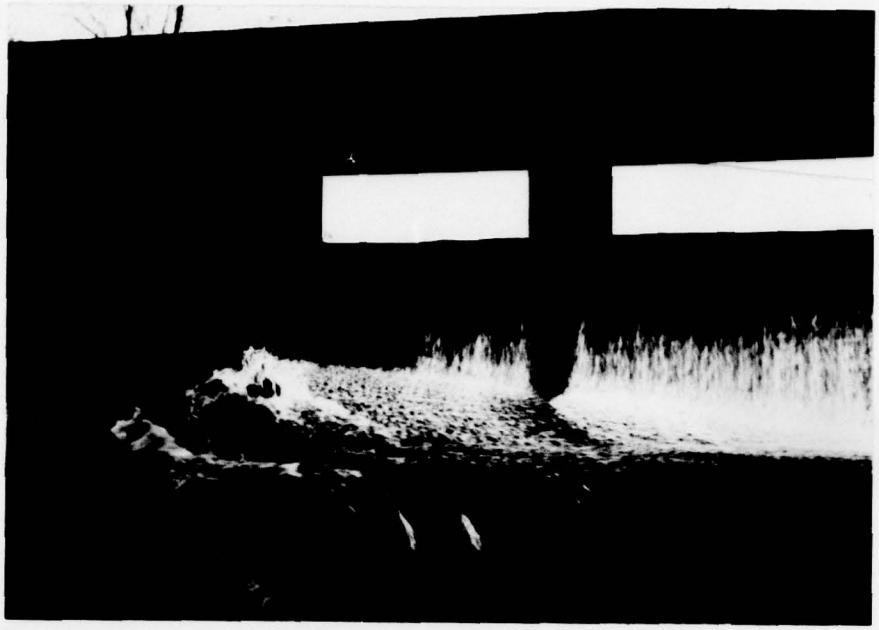


Photo No. 3 - Detail of right spillway. Note the deteriorated concrete at the foot of the bridge pier, the smooth overall flow, the good condition of the bridge and the minor debris on the apron.

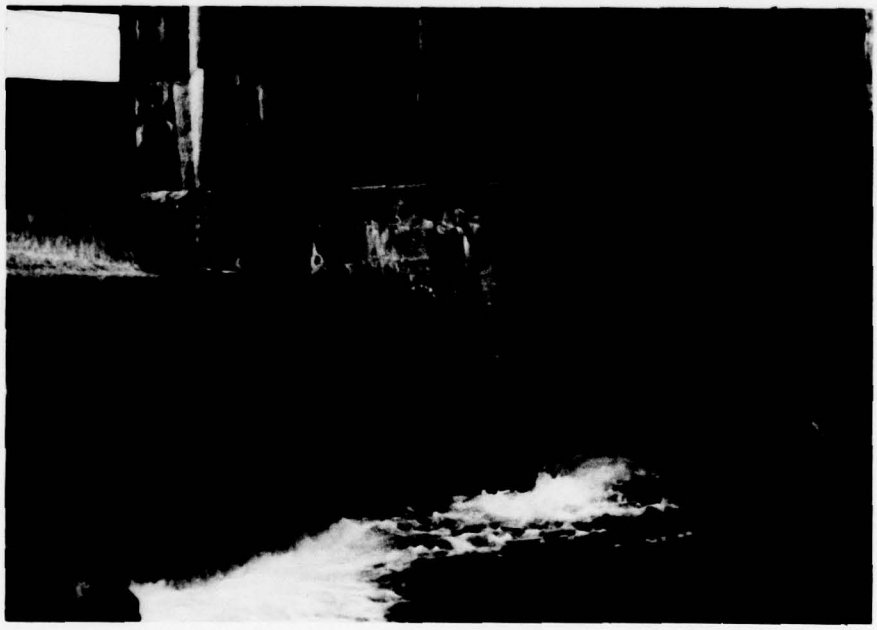


Photo No. 4 - Detail of gatehouse foundation, showing the spalled concrete at the water line, and the leak in the central sluice.

Photo No. 5 - Detail showing the upstream side of the gatehouse. Note the headwater gage, the lifting gantry for the trash screens, and the good exterior condition of the house.

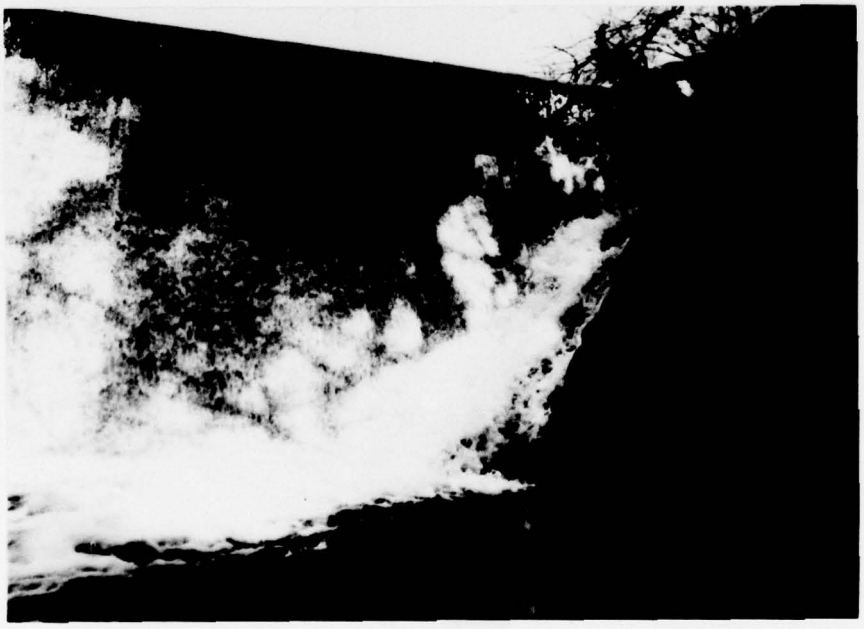


Photo No. 6 - Detail of the left rock abutment, showing the tree lodged at the spillway crest, and the smooth flow on the spillway.

Photo No. 7 - View of upstream side of the footbridge to the gatehouse. Note the lake bottom upstream of the right spillway.

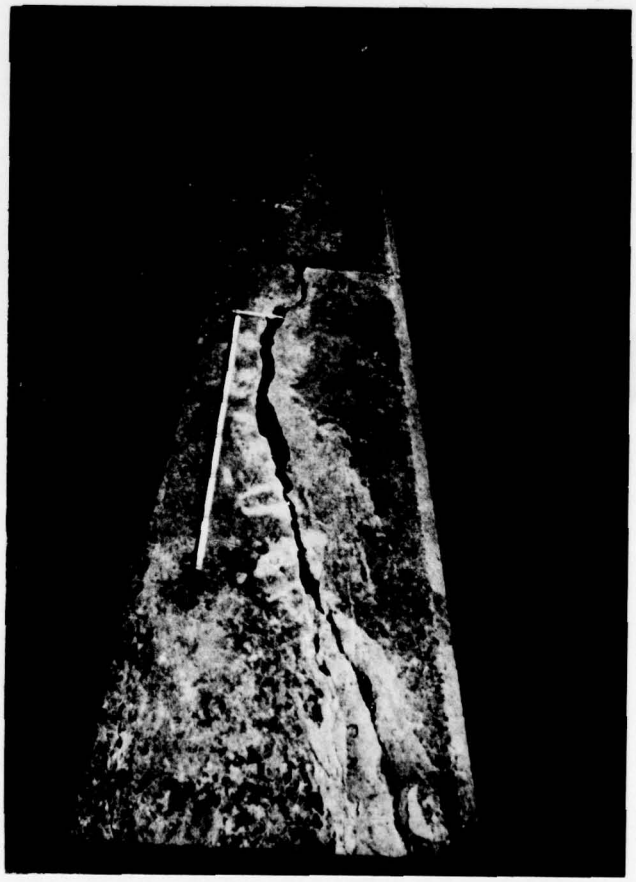


Photo No. 8 - Detail showing the movement crack in the right wingwall, upstream of the footbridge.

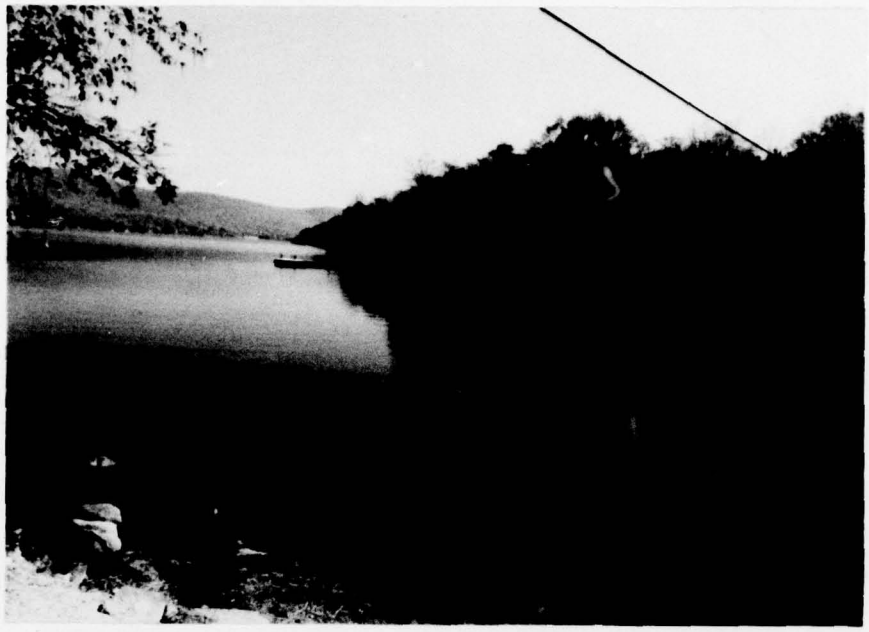


Photo No. 9 - Overall view of Greenwood Lake looking upstream. Note the shoreline buildings and boat stages.

Photo No. 10 - View of downstream channel - Wanaque River. Note the steep, rocky banks and the tree growth.

Photo No. 11 - View of the U.S.G.S. flow-measurement weir approximately 600' downstream of the dam. Note the gage and the walled venturi channel.

Photo No. 12 - View of the U.S.G.S. Gage Station at the weir.

APPENDIX C

SUMMARY OF ENGINEERING DATA

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

Name of Dam: Greenwood Lake Dam (Wanaque River)

Drainage Area Characteristics: Woodland, with residential development around the lake.

Elevation Top Normal Pool (Storage Capacity): 635.52' MSL (13,269 acre-feet)

Elevation Top Flood Control Pool (Storage Capacity): N/A

Elevation Maximum Design Pool: (SDF) 640.77' MSL (24,556 acre-feet)

Elevation Top Dam: 639.10' MSL (20,490 acre-feet)

SPILLWAY CREST

a. Elevation 635.52' MSL

b. Type Two concrete ogees.

c. Width 2'

d. Length 120' (effective)

e. Location Spillover Full length, both side of gatehouse.

f. No. and Type of Gates N/A

OUTLET WORK

a. Type 2 manually operated, rising stem sluice gates 60" x 42".

b. Location Contained in gatehouse at center of dam.

c. Entrance Inverts 621.5' MSL

d. Exit Inverts 621.5' MSL

e. Emergency Draindown Facilities None.

HYDROMETEOROLOGICAL GAGES

a. Type N/A

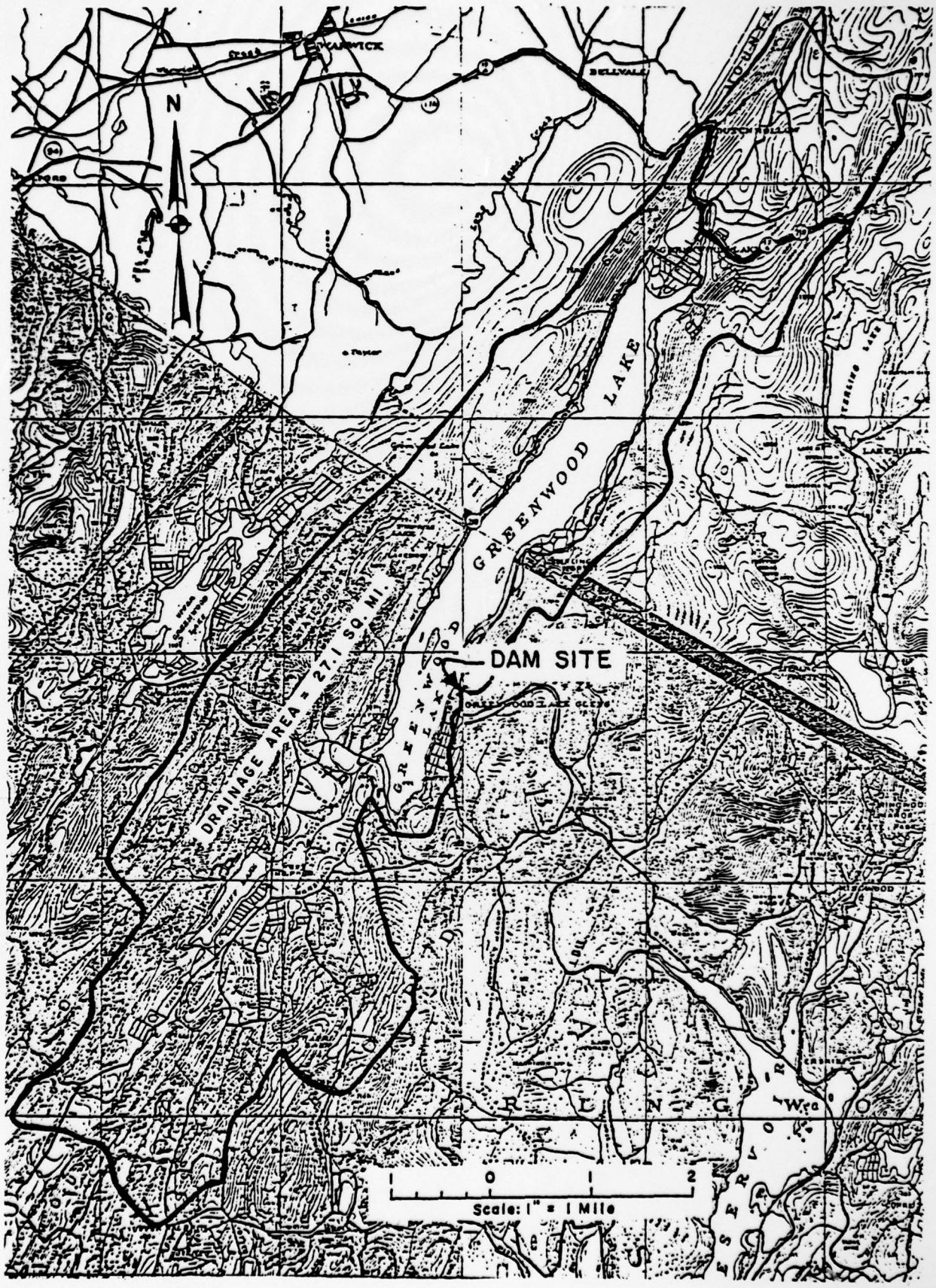
b. Location N/A

c. Records N/A

MAXIMUM NON-DAMAGING DISCHARGE 3089 cfs

APPENDIX D

HYDROLOGIC COMPUTATIONS



GREENWOOD LAKE DAM
DRAINAGE BASIN

Area of the Lake at normal pool level:

(Area measured from U.S.G.S quad (EL 635.52)

= 1733 Ac

Height of Dam = From Top of Dam to Toe of Apron

≈ 97.58 - 80.94 ≈ 16.64 ft

Intermediate Dam, Significant Hazard

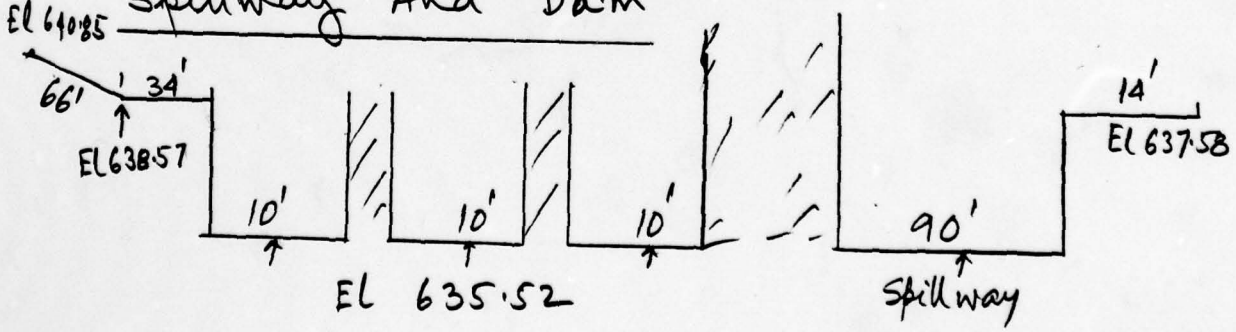
S.D.F = ½ PMF

Hydrologic analysis :—

D.A = 27.1 sq. miles.

Inflow Hydrograph at Reservoir was determined using HEC 1-DB program. Inflow routed through reservoir.

Spillway And Dam

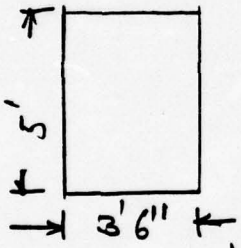


Low Level outlet

Greenwood Lake Dam was designed with 3 sluice gate controlled, low level outlets. 2 of the gates are 60" x 42" and lead directly into the downstream channel.

Invert ~~el~~ elevation = 14' below spillway crest ie, 621.52 El.

The third gate is 42" x 42" is also located in the bottom of the dam. This gate leads to a penstock and seems to be not operational



2 nos of low level outlet

The 2 - 60" x 42" sluice gates are only opened when the reservoir level drops below the spillway crest.

So for High flow above spillway crest the gate is kept closed.

Effective length of spillway = 120'

Elevation = 635.52

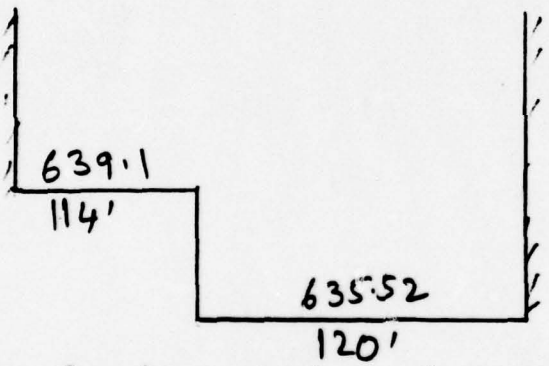
Effective length of Dam = 114'

Weighted Elevation $= \dfrac{\left(637.58 \times 14 + 638.57 \times 34 + \dfrac{640.85 + 638.57}{2} \times 66\right)}{114}$

$= 639.1$ *

Schematic for spillway rating curve

Input for HEC 1-DB

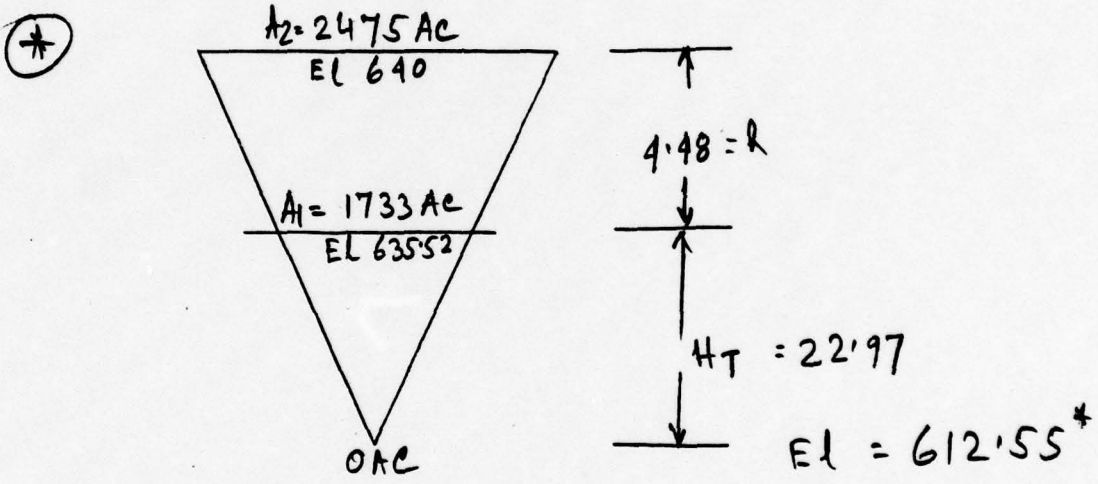


Low level outlet closed when the flow is over spillway.

* Note that top of the dam could be modeled exactly. But as it is convenient to get the rating curve by HEC 1-DB program, an average (weighted) elevation is considered and this will not affect the result appreciably.

Reservoir Stage Area Relations

Elevation	Area in Acres.
*612.55	0 A/c
635.52	1733 Ac
640	2475 Ac
660	2850 Ac



$$H_T = h / \left(\sqrt{A_2/A_1} - 1\right)$$

$$= \frac{4.48}{\sqrt{\frac{2475}{1733}} - 1} = 22.97$$

* Estimated.

Determination of PMP

PMP amount from HMS Report 33

= 22" (200 sq mile - 24 hrs all season envelope)

Depth area duration relationship Percentage to be applied to the above figure. (D.A 27.1 SM)

Zone 6

6 hr	=	104 %
12 hr	=	112 %
24 hr	=	122 %
48 hr	=	132 %

(The location of the dam is in zone 6, almost at the boundary of zone 1. As the Dam is closer to zone 6 rather than 1, PMP values of zone 6 is considered, rather than the average of 1 & 6)

<u>For U.H.G</u>

Snyders Coefficient assumed

$C_p = 0.62$

$C_t = 2.0$

$t_p = C_t (L L_c)^{0.3}$

$= 2.0 (7.5 \times .9)^{0.3}$

$= 3.55$ hrs.

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

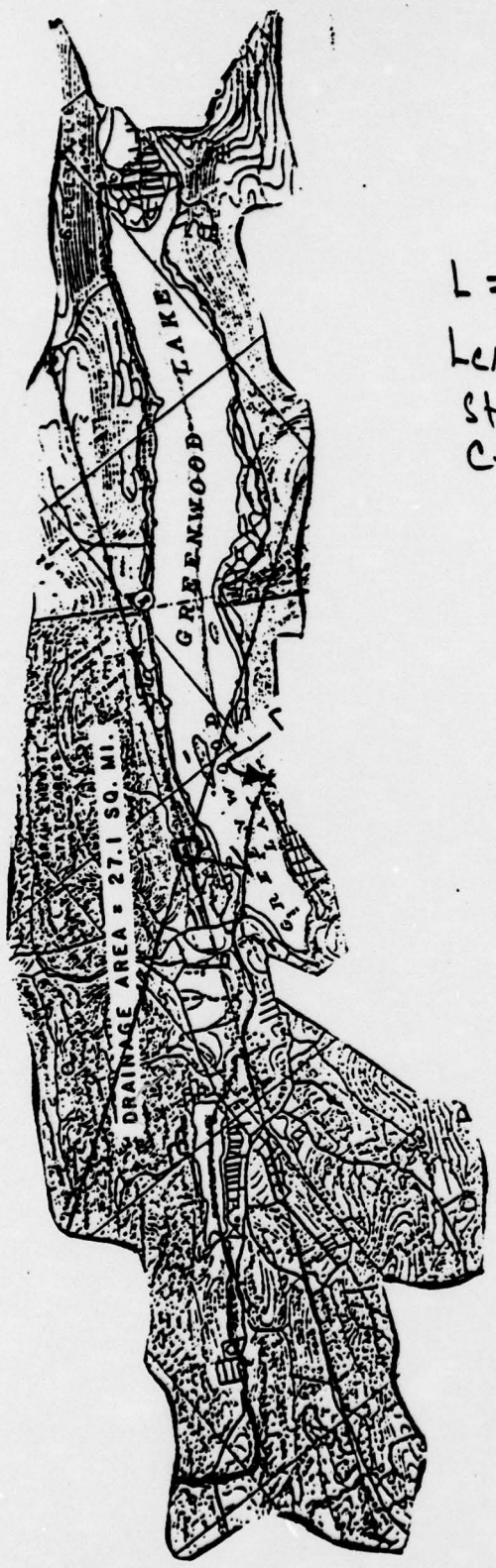
SUBJECT N.J. Dam Inspection
Greenwood Lake

COMPUTED BY S.B. CHECKED BY

SHEET NO. 6 OF

JOB NO. 10-A 20-01

DATE Aug., 1979



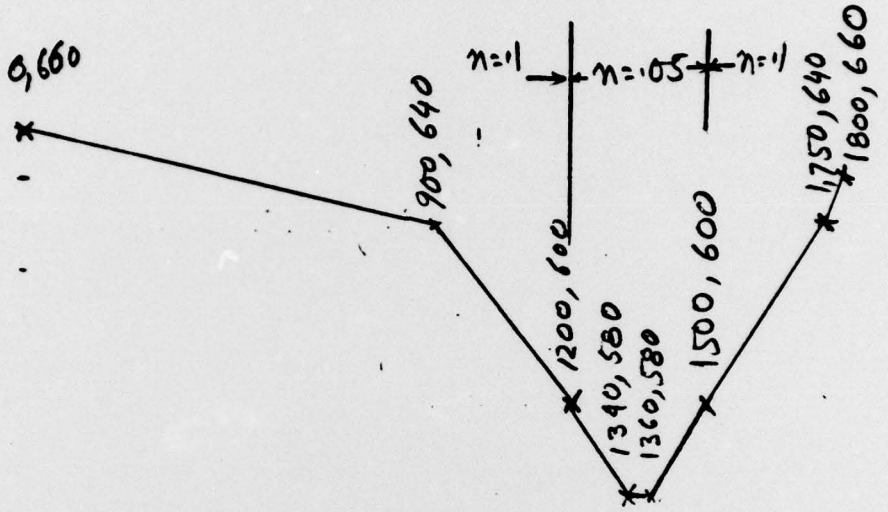
L = Length of Stream = 7.5 mile

LCA = River milage from Station to the opposite of C.G of D.A = 19 miles

1 0 1 2
Scale: 1" = 1 Mile

GREENWOOD LAKE DAM
DRAINAGE BASIN

Cross Section at D/S Reach

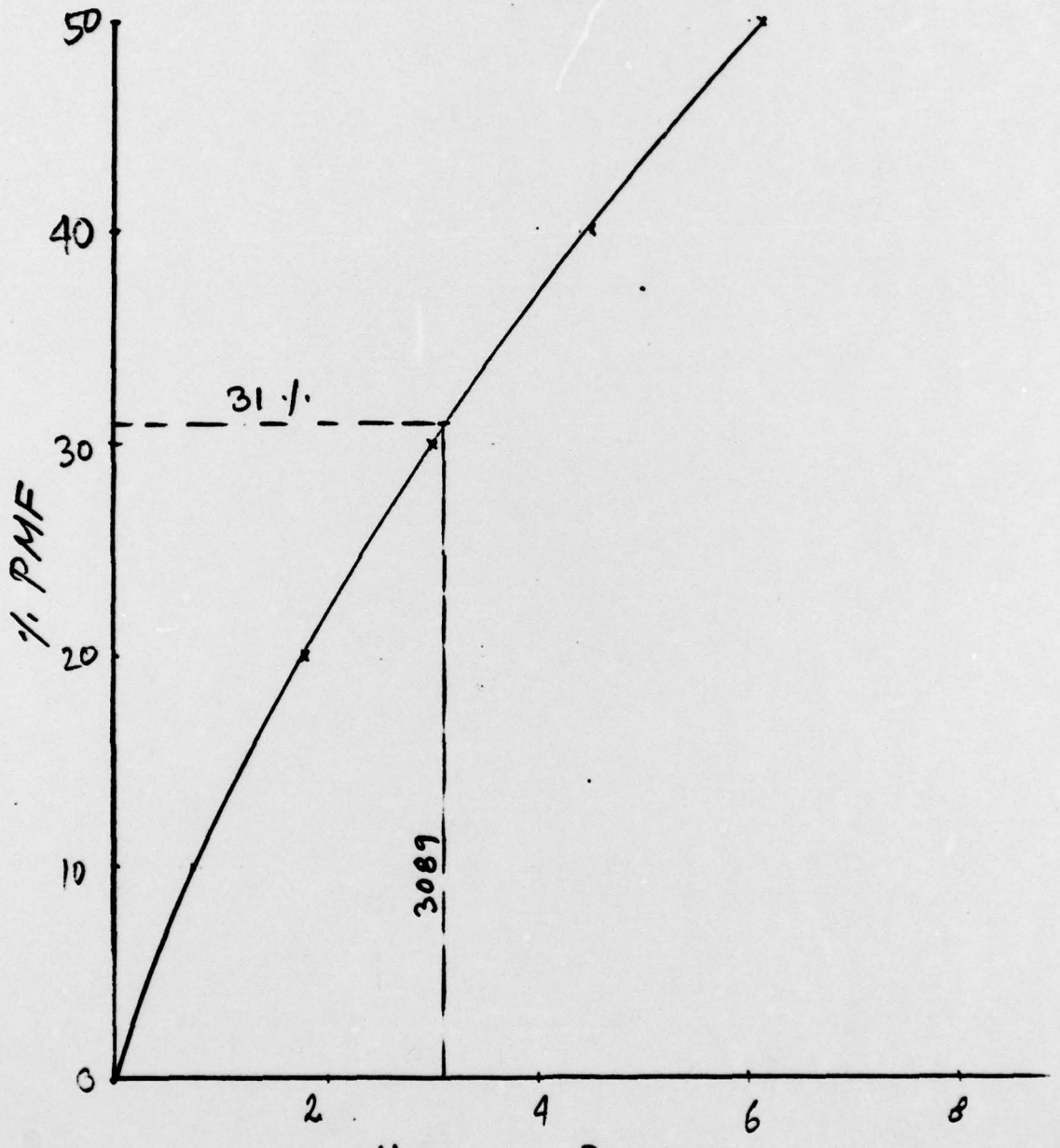


Slope = .00625

Cross section of reach 1 at 6000 ft D/S of Dam. This is the first downstream point of confluence of the Wanaque River with a tributary. The hazard location is at Hewitt about 2½ miles downstream. At this location, about one or two houses are estimated as being in the flood path, and the hazard potential of "significant" is appropriate.

No breach analysis is required for a "significant" hazard dam.

Overtopping Potential



Outflow in 10^3 cfs.

Overtopping of the Dam occurs at El 639.10
Q = 3089 cfs (31 % of PMF)

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection
Sykesowood Lake Dam
COMPUTED BY S.B. CHECKED BY

SHEET NO. 9 OF
JOB NO. 12-A20-01
DATE Aug., 1979

Overtopping Over the Dam

% PMF	Q	Max W.S El.	Max Feet above Dam	Duration of Flooding	Max W.S El 6000 ft D/s
10	721	636.88	0	0	583.7
20	1797	638.02	0	0	585.6
30	2995	639.03	0	0	587.1
40	4471	639.94	.84	3.75	588.4
50	6161	640.77	1.67	4.75	589.6

Reservoir Evaluation

a) Discharge Vs. Head.

Gates are 60" x 42"

Area = 5 x 3.5 x 2 = 35 sq ft.

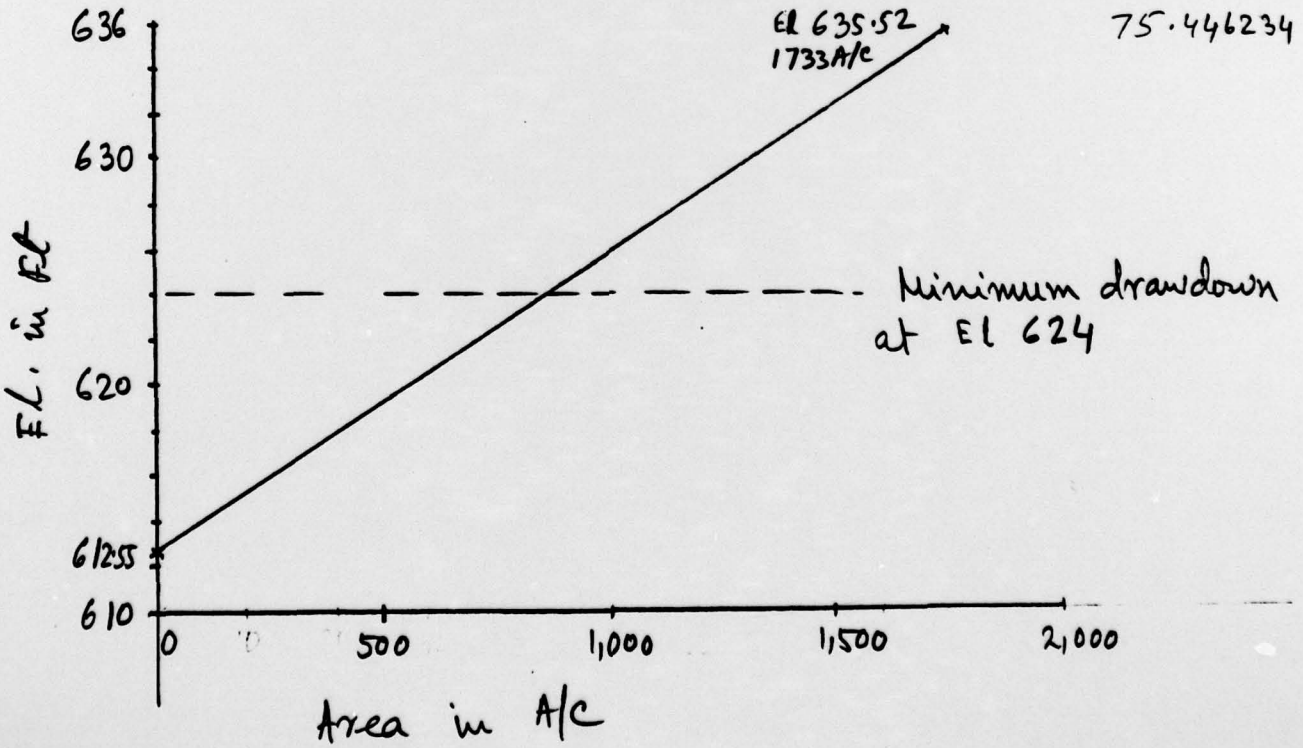
$Q = C_d A \times \sqrt{2gh}$

$= .85 \times 35 \times 8 \sqrt{h}$

$= 238 \sqrt{h}$

b) Area Vs Head

Assume a straight line relationship from normal water surface to the streambed.



Invert elevation 621.52

Tailwater assumed at half depth of outlet

$621.52 + 2.5 = 624$

c) Drainage Area = 27.1 sq miles
Inflow = 2 cfs / sq miles
= 54.2 cfs

El.	Area (AC)	Av. Area (AC)	Vol AF	Head on outlet h(Ft)	Outlet Q $238\sqrt{h}$ cfs.	Time to draw to, $\frac{Vol \times 24}{1.98 \times Q}$ (hrs)	Time to draw 54.2 cfs $\frac{54.2 \times t_1}{Q}$ t_2 (hrs)	Total time $t_1 + t_2$
635.52	1733							
		1657.5	3315	10.52	772	52	3.7	55.7
633.52	1582							
		1506.5	3013	8.52	695	52.5	4.1	56.6
631.52	1431							
		1355.5	2711	6.52	608	54	4.8	58.8
629.52	1280							
		1204.5	2409	4.52	506	57.7	6.2	63.9
627.52	1129							
		1053.5	2107	2.52	378	67.6	9.7	77.3
625.52	978							
		920.5	1399	0.76	207	81.9	21.4	103.3
624.00	863							
						365.7		415.6

Time of drawdown with no inflow
= 366 hrs = 15 days 6 hrs.
Time of drawdown with inflow of 2 cfs/SM
= 416 hrs = 17 days 8 hrs.

HEC1-DB

COMPUTER PRINT-OUT

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
```

```
     1                A1      N.J. DAM INSPECTION
     2                A2      GREENWOOD LAKE DAM
     3                A3      MULTIRATIO PMF ROUTING
     4                B    100       0       15        0        0        0        0        0        0        0
     5                B1     5
     6                J      1       5        1
     7                J1    .5      .4       .3       .2       .1
     8                K      0     RES                                        1
     9                K1      LOCAL INFLOW TO RES.
    10                M      1       1     27.1                27.1
    11                P      0      22      104      112      122      132
    12                T                                                  .6      .02
    13                W   3.55     .62
    14                X     -1    -.05        2
    15                K      1      DAM                                        1
    16                K1      ROUTED THROUGH DAM
    17                Y                                  1        1
    18                Y1     1                                          -635.52        0
    19                $A     0    1733     2475     2850
    20                $E612.55  635.52      640      660
    21                $S635.52     120      3.0      1.5
    22                $D639.10    2.75      1.5      114
    23                K      1   REACH                                      1
    24                K1      CHANNEL ROUTING BY MOD. PULLS
    25                Y                                  1        1
    26                Y1     1
    27                Y6    .1     .05       .1      580      600     6000    .00625
    28                Y7     0     660      900      640     1200      600     1340      580     1360      580
    29                Y7  1500     600     1750      640     1800      660
    30                K     99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT RES
ROUTE HYDROGRAPH TO DAM
ROUTE HYDROGRAPH TO REACH
END OF NETWORK

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN  DATE= 79/08/07.
     TIME= 14.24.58.


                    N.J. DAM INSPECTION
                    GREENWOOD LAKE DAM
                    MULTIRATIO PMF ROUTING

                                JOB SPECIFICATION
      NQ      NHR     NMIN     IDAY     IHR     IMIN    METRC     IPLT     IPRT    NSTAN
     100       0       15        0       0        0        0        0        0        0
                                JOPER      NWT   LROPT   TRACE
                                    5        0       0       0


                            MULTI-PLAN ANALYSES TO BE PERFORMED
                                NPLAN= 1 NRTIO= 5 LRTIO= 1
                RTIOS=     .50     .40     .30     .20     .10


**********          **********          **********          **********          **********

                            SUB-AREA RUNOFF COMPUTATION

                LOCAL INFLOW TO RES.

                          ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                            RES       0       0       0       0       1       0       0


                                HYDROGRAPH DATA
          IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
              1       1   27.10    0.00   27.10    0.00   0.000       0       0       0


                                PRECIP DATA
                        SPFE     PMS      R6     R12     R24     R48     R72     R96
                        0.00   22.00  104.00  112.00  122.00  132.00    0.00    0.00
TRSPC COMPUTED BY THE PROGRAM IS  .832


                                LOSS DATA
          LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
              0    0.00    0.00    1.00    0.00    0.00    1.00     .60     .02    0.00    0.00


                            UNIT HYDROGRAPH DATA
                        TP=  3.55    CP= .62    NTA=  0


                                RECESSION DATA
                        STRTQ=   -1.00    QRCSN=    -.05    RTIOR= 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=15.56 AND R=13.47 INTERVALS

          UNIT HYDROGRAPH 80 END-OF-PERIOD ORDINATES, LAG=   3.57 HOURS, CP=  .62  VOL= 1.00
    58.     217.     443.     710.    1004.    1318.    1647.    1986.    2309.    2587.
  2809.    2976.    3089.    3143.    3130.    3018.    2826.    2624.    2436.    2262.
  2100.    1949.    1810.    1680.    1560.    1448.    1345.    1248.    1159.    1076.
   999.     927.     861.     799.     742.     689.     640.     594.     551.     512.
   475.     441.     410.     380.     353.     328.     304.     283.     262.     244.
   226.     210.     195.     181.     168.     156.     145.     134.     125.     116.
   108.     100.      93.      86.      80.      74.      69.      64.      59.      55.
```

51. 48. 44. 41. 38. 35. 33. 30. 28. 26.

END-OF-PERIOD FLOW

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.15	1	.00	0.00	.00	25.	1.02	.15	97	.03	.03	.01	889.
1.01	.30	2	.00	0.00	.00	24.	1.02	.30	98	.03	.03	.01	831.
1.01	.45	3	.00	0.00	.00	22.	1.02	.45	99	.03	.03	.01	783.
1.01	1.00	4	.00	0.00	.00	21.	1.02	1.00	100	.03	.03	.01	747.
1.01	1.15	5	.00	0.00	.00	19.	0.00	0.00	101	.03	.03	.01	721.
1.01	1.30	6	.00	0.00	.00	18.	0.00	0.00	102	.03	.03	.01	708.
1.01	1.45	7	.00	0.00	.00	17.	0.00	0.00	103	.03	.03	.01	706.
1.01	2.00	8	.00	0.00	.00	16.	0.00	0.00	104	.03	.03	.01	716.
1.01	2.15	9	.00	0.00	.00	15.	0.00	0.00	105	.03	.03	.01	737.
1.01	2.30	10	.00	0.00	.00	14.	0.00	0.00	106	.03	.03	.01	768.
1.01	2.45	11	.00	0.00	.00	13.	0.00	0.00	107	.03	.03	.01	807.
1.01	3.00	12	.00	0.00	.00	12.	0.00	0.00	108	.03	.03	.01	853.
1.01	3.15	13	.00	0.00	.00	11.	0.00	0.00	109	.03	.03	.01	904.
1.01	3.30	14	.00	0.00	.00	10.	0.00	0.00	110	.03	.03	.01	958.
1.01	3.45	15	.00	0.00	.00	10.	0.00	0.00	111	.03	.03	.01	1014.
1.01	4.00	16	.00	0.00	.00	9.	0.00	0.00	112	.03	.03	.01	1068.
1.01	4.15	17	.00	0.00	.00	8.	0.00	0.00	113	.03	.03	.01	1119.
1.01	4.30	18	.00	0.00	.00	8.	0.00	0.00	114	.03	.03	.01	1167.
1.01	4.45	19	.00	0.00	.00	7.	0.00	0.00	115	.03	.03	.01	1211.
1.01	5.00	20	.00	0.00	.00	7.	0.00	0.00	116	.03	.03	.01	1252.
1.01	5.15	21	.00	0.00	.00	6.	0.00	0.00	117	.03	.03	.01	1290.
1.01	5.30	22	.00	0.00	.00	6.	0.00	0.00	118	.03	.03	.01	1326.
1.01	5.45	23	.00	0.00	.00	6.	0.00	0.00	119	.03	.03	.01	1359.
1.01	6.00	24	.00	0.00	.00	5.	0.00	0.00	120	.03	.03	.01	1389.
1.01	6.15	25	.01	0.00	.01	5.	0.00	0.00	121	.06	.06	.01	1419.
1.01	6.30	26	.01	0.00	.01	4.	0.00	0.00	122	.06	.06	.01	1452.
1.01	6.45	27	.01	0.00	.01	4.	0.00	0.00	123	.06	.06	.01	1490.
1.01	7.00	28	.01	0.00	.01	4.	0.00	0.00	124	.06	.06	.01	1534.
1.01	7.15	29	.01	0.00	.01	4.	0.00	0.00	125	.06	.06	.01	1586.
1.01	7.30	30	.01	0.00	.01	3.	0.00	0.00	126	.06	.06	.01	1646.
1.01	7.45	31	.01	0.00	.01	3.	0.00	0.00	127	.06	.06	.01	1714.
1.01	8.00	32	.01	0.00	.01	3.	0.00	0.00	128	.06	.06	.01	1791.
1.01	8.15	33	.01	0.00	.01	3.	0.00	0.00	129	.06	.06	.01	1878.
1.01	8.30	34	.01	0.00	.01	3.	0.00	0.00	130	.06	.06	.01	1971.
1.01	8.45	35	.01	0.00	.01	2.	0.00	0.00	131	.06	.06	.01	2070.
1.01	9.00	36	.01	0.00	.01	2.	0.00	0.00	132	.06	.06	.01	2173.
1.01	9.15	37	.01	0.00	.01	2.	0.00	0.00	133	.06	.06	.01	2279.
1.01	9.30	38	.01	0.00	.01	2.	0.00	0.00	134	.06	.06	.01	2386.
1.01	9.45	39	.01	0.00	.01	2.	0.00	0.00	135	.06	.06	.01	2492.
1.01	10.00	40	.01	0.00	.01	2.	0.00	0.00	136	.06	.06	.01	2593.
1.01	10.15	41	.01	0.00	.01	2.	0.00	0.00	137	.06	.06	.01	2688.
1.01	10.30	42	.01	0.00	.01	1.	0.00	0.00	138	.06	.06	.01	2775.
1.01	10.45	43	.01	0.00	.01	1.	0.00	0.00	139	.06	.06	.01	2856.
1.01	11.00	44	.01	0.00	.01	1.	0.00	0.00	140	.06	.06	.01	2930.
1.01	11.15	45	.01	0.00	.01	1.	0.00	0.00	141	.06	.06	.01	3000.
1.01	11.30	46	.01	0.00	.01	1.	0.00	0.00	142	.06	.06	.01	3063.
1.01	11.45	47	.01	0.00	.01	1.	0.00	0.00	143	.06	.06	.01	3116.
1.01	12.00	48	.01	0.00	.01	1.	0.00	0.00	144	.06	.06	.01	3172.
1.01	12.15	49	.04	0.00	.04	1.	0.00	0.00	145	.48	.47	.01	3248.
1.01	12.30	50	.04	0.00	.04	1.	0.00	0.00	146	.48	.47	.01	3386.
1.01	12.45	51	.04	0.00	.04	1.	0.00	0.00	147	.48	.47	.01	3615.
1.01	13.00	52	.04	0.00	.04	1.	0.00	0.00	148	.48	.47	.01	3951.
1.01	13.15	53	.05	0.00	.05	1.	0.00	0.00	149	.57	.57	.01	4413.
1.01	13.30	54	.05	0.00	.05	1.	0.00	0.00	150	.57	.57	.01	5017.
1.01	13.45	55	.05	0.00	.05	1.	0.00	0.00	151	.57	.57	.01	5776.
1.01	14.00	56	.05	0.00	.05	1.	0.00	0.00	152	.57	.57	.01	6699.
1.01	14.15	57	.06	0.00	.06	1.	0.00	0.00	153	.71	.71	.01	7792.
1.01	14.30	58	.06	.04	.02	3.	0.00	0.00	154	.71	.71	.01	9050.
1.01	14.45	59	.06	.05	.01	12.	0.00	0.00	155	.71	.71	.01	10461.
1.01	15.00	60	.06	.05	.01	32.	0.00	0.00	156	.71	.71	.01	12011.
1.01	15.15	61	.06	.05	.01	65.	0.00	0.00	157	.72	.72	.01	13679.

1.01	15.30	62	.12	.11	.01	1110.	0.00	0.00	158	1.01	1.01	.01	15405.
1.01	15.45	63	.33	.33	.01	209.	0.00	0.00	159	4.05	4.05	.01	17615.
1.01	16.00	64	.08	.08	.01	350.	0.00	0.00	160	1.01	1.01	.01	20169.
1.01	16.15	65	.05	.05	.01	533.	0.00	0.00	161	.67	.66	.01	22982.
1.01	16.30	66	.05	.05	.01	747.	0.00	0.00	162	.67	.66	.01	25921.
1.01	16.45	67	.05	.05	.01	985.	0.00	0.00	163	.67	.66	.01	28920.
1.01	17.00	68	.05	.05	.01	1242.	0.00	0.00	164	.67	.66	.01	31932.
1.01	17.15	69	.04	.04	.01	1512.	0.00	0.00	165	.52	.52	.01	34914.
1.01	17.30	70	.04	.04	.01	1789.	0.00	0.00	166	.52	.52	.01	37808.
1.01	17.45	71	.04	.04	.01	2058.	0.00	0.00	167	.52	.52	.01	40494.
1.01	18.00	72	.04	.04	.01	2307.	0.00	0.00	168	.52	.52	.01	42839.
1.01	18.15	73	.00	0.00	.00	2525.	0.00	0.00	169	.05	.04	.01	44767.
1.01	18.30	74	.00	0.00	.00	2704.	0.00	0.00	170	.05	.04	.01	46231.
1.01	18.45	75	.00	0.00	.00	2839.	0.00	0.00	171	.05	.04	.01	47201.
1.01	19.00	76	.00	0.00	.00	2927.	0.00	0.00	172	.05	.04	.01	47648.
1.01	19.15	77	.00	0.00	.00	2965.	0.00	0.00	173	.05	.04	.01	47516.
1.01	19.30	78	.00	0.00	.00	2945.	0.00	0.00	174	.05	.04	.01	46717.
1.01	19.45	79	.00	0.00	.00	2877.	0.00	0.00	175	.05	.04	.01	45363.
1.01	20.00	80	.00	0.00	.00	2782.	0.00	0.00	176	.05	.04	.01	43722.
1.01	20.15	81	.00	0.00	.00	2673.	0.00	0.00	177	.05	.04	.01	41921.
1.01	20.30	82	.00	0.00	.00	2551.	0.00	0.00	178	.05	.04	.01	39997.
1.01	20.45	83	.00	0.00	.00	2420.	0.00	0.00	179	.05	.04	.01	37986.
1.01	21.00	84	.00	0.00	.00	2283.	0.00	0.00	180	.05	.04	.01	35927.
1.01	21.15	85	.00	0.00	.00	2143.	0.00	0.00	181	.05	.04	.01	33857.
1.01	21.30	86	.00	0.00	.00	2003.	0.00	0.00	182	.05	.04	.01	31803.
1.01	21.45	87	.00	0.00	.00	1865.	0.00	0.00	183	.05	.04	.01	29795.
1.01	22.00	88	.00	0.00	.00	1732.	0.00	0.00	184	.05	.04	.01	27877.
1.01	22.15	89	.00	0.00	.00	1608.	0.00	0.00	185	.05	.04	.01	26085.
1.01	22.30	90	.00	0.00	.00	1493.	0.00	0.00	186	.05	.04	.01	24421.
1.01	22.45	91	.00	0.00	.00	1386.	0.00	0.00	187	.05	.04	.01	22876.
1.01	23.00	92	.00	0.00	.00	1287.	0.00	0.00	188	.05	.04	.01	21442.
1.01	23.15	93	.00	0.00	.00	1195.	0.00	0.00	189	.05	.04	.01	20110.
1.01	23.30	94	.00	0.00	.00	1109.	0.00	0.00	190	.05	.04	.01	18874.
1.01	23.45	95	.00	0.00	.00	1030.	0.00	0.00	191	.05	.04	.01	17726.
1.02	0.00	96	.00	0.00	.00	956.	0.00	0.00	192	.05	.04	.01	16661.
									SUM	24.17	22.93	1.24	1364730.
										(614.)	(582.)	(32.)	(38644.85)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	47648.	38187.	13482.	7064.	1356381.
CMS	1349.	1081.	382.	200.	38408.
INCHES		13.11	18.51	19.40	19.40
MM		332.95	470.18	492.75	492.75
AC-FT		18936.	26741.	28024.	28024.
THOUS CU M		23357.	32984.	34568.	34568.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .50	RATIO 2 .40	RATIO 3 .30	RATIO 4 .20	RATIO 5 .10
HYDROGRAPH AT	RES	27.10 (70.19)	1	23824. (674.62)	19059. (539.69)	14294. (404.77)	9530. (269.85)	4765. (134.92)
ROUTED TO	DAM	27.10 (70.19)	1	6161. (174.47)	4471. (126.60)	2995. (84.81)	1797. (50.89)	721. (20.41)
ROUTED TO	REACH	27.10 (70.19)	1	6130. (173.59)	4440. (125.73)	2973. (84.18)	1780. (50.41)	710. (20.11)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	635.52	635.52	639.10
STORAGE	13269.	13269.	20490.
OUTFLOW	0.	0.	3089.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	640.77	1.67	24556.	6161.	4.75	48.00	0.00
.40	639.94	.84	22487.	4471.	3.75	48.00	0.00
.30	639.03	0.00	20322.	2995.	0.00	48.00	0.00
.20	638.02	0.00	18080.	1797.	0.00	48.00	0.00
.10	636.88	0.00	15762.	721.	0.00	48.00	0.00

PLAN 1 STATION REACH

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	6130.	589.6	48.00
.40	4440.	588.4	48.00
.30	2973.	587.1	48.00
.20	1780.	585.6	48.00
.10	710.	583.7	48.00